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PIAGET'S CONCEPTION OF LOGICAL DEVELOPMENT
AND ITS RELATION TO COMPREHENSION IN READING

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Piaget's Conception of Logical Development and Its Relation to Comprehension in Reading," submitted by Hildred I. Rawson in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

PIAGET'S CONCEPTION OF LOGICAL DEVELOPMENT
AND ITS RELATION TO COMPREHENSION IN READING

The purpose of this study was to identify the bases of interaction between reading and logical development at the concrete level, and to consider the effect of these interactions on reading comprehension and on progress in logical thinking. Problems of timing and of the selection of materials and procedures for instruction in reading were considered in relation to logical development.

The study has been based on distinguished research in a number of fields: Piaget's extensive research on the classificatory basis of intelligence; recent studies of a generative grammar of English; some aspects of symbolic logic; and professional recognition of the problems presented by universal public instruction in reading.

Piaget's account of the construction of intelligence at the concrete level has represented the child as firmly committed to his own intellectual development - the only alternative to establishing a basis for intelligent behavior being social isolation. It was therefore necessary to inquire what program the child himself had adopted prior to the introduction of reading, in his effort to achieve emancipation from primitive forms of thinking.

Piaget has shown that between the ages of five and eight years the child will undertake a near-total revision of his world-view, including his concept of himself, his concept of the properties of objects in his environment and his orientation to the nature of causality. This finding has been confirmed in a recent carefully controlled study conducted by Laurendeau and Pinard and based on a sample of Montreal children.

Piaget has further investigated the conditions which appear to be critical for the replacement of primitive egocentered notions and for the subsequent establishment of a classificatory basis for intelligence. The significant conditions included:

1. The confrontation of peers.
2. Action-on-objects accompanied by representation in images and symbolic encoding.
3. The circumstance of two contrasting patterns of learning - patterns which continue to be operative throughout the concrete period - namely, substitution and filiation.

It has been shown that the entire elementary school period is required for a clear transition from animistic, almost exclusively teleological notions of the world and of causality to scientifically oriented concepts. This transition "underwrites" the acquisition of invariance as a property of objects as well as the construction of logical classes and relations and the emergence of implicative thinking. It appeared, therefore, that the possibility should be considered that

such a rate of change has represented a serious cultural lag. In particular it would be important to consider the possibility that the potentialities of abstract printed signs in accelerating this transition have not yet been fully explored.

The role of reading in assisting the child to construct his intelligence was further investigated in relation to the development of the logic of classes and relations: to class inclusion relations; the correct use of the quantifying terms "some," "every," "all," and the hierarchical class structure. Materials and instructional procedures currently recommended in the reading program were found to be at variance with certain sequences and processes essential in the emergence of logical thinking. The conflict appeared in particular in three areas of logical operations:

1. The emergence of implicative thinking.
2. The efficiency of training in "loyalty to the given."
3. The recognition of the logical structure of a communication as a whole.

Parallel with the construction of hierarchical class relations there is the acquisition of multiplicative classification and the realization of the matrix structure. This process and its interdependence with reading has therefore been examined.

One aspect of this problem was considered in relation to recent studies of a generative grammar of English. A multiplicative class appears in a sentence which is derived by the embedding (with deletion)

of constituent sentences in a basic sentence. The implicit knowledge of the rules of the grammar which has enabled the child to construct such a sentence was found to be only a part of the total operation required for comprehension in reading. There is, in addition, the logical construction of the multiplicative class itself. There is also, for comprehension, the selection and reconstruction of a matrix to which the class is related and which is specific to this communication. This matrix is not "visible" in the printed communication, and not "given" in the grammatical structure.

The significance of the construction of intersecting classes and relations for the understanding of conjunction, disjunction and negation was examined. These logical operations are required for the comprehension of compound sentences. They are associated with "small" words which may be overlooked in instruction. These "simple" words (and, or, not, if) call for relational thinking of considerable complexity. Other connectives are logically related to these and convey as well subtle nuances of meaning (though, unless, yet, but, etc.). Connectives also link sentences and paragraphs (now, so, moreover, however, the full stop, etc.) and require complicated logical thinking for comprehension in reading.

The limitations of the logic of classes and relations in the solution of presented problems was also considered. It was found that the logic available at the concrete level was indispensable for all later intelligent behavior, but it was also currently limited in power. Certain conditions at the end of the concrete period appeared

to facilitate a breakthrough, giving the child access to the more powerful abstract logic of the formal level of operations.

The most important of these conditions was shown to be competence in the logic of classes and relations of the concrete period. The child who possesses this tool struggles with its limitations. The breakthrough proceeds from a position of strength.

This circumstance has added greatly to the importance to be attached to logical development in the elementary school years. It was suggested that reading could accept increasing responsibility in this area. Some readily available modifications of present instructional procedures were suggested for this purpose.

But the critical revisions necessary to implement such a role for reading would require a coordinated experimental approach, one which would combine recent advances in the knowledge of logical development, of grammatical structure and of the reading process.

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CHAPTER I.

INTRODUCTION

THE PROBLEM

Problems of comprehension in reading are, at the earlier stages, unlikely to be the result of a restricted oral vocabulary or of a lack of control of the basic grammatical structures of the spoken language.¹ Since considerable care is taken in selecting reading materials based on the familiar experiences and interests of the child, difficulties in understanding what is read are expected to be minimal.

Nevertheless difficulties in comprehension are almost always present.² They appear to increase as the logical relations between sentences and within the sentence increase in complexity. On the basis of Piaget's study of the child's intellectual development, however, it is reasonable to expect that at the end of the elementary school years the simple classificatory skills which underlie reading comprehension will have been acquired. In addition, the child will have replaced all or most of his early primitive notions.

¹ Ruth G. Strickland, The Language of Elementary School Children: Its Relationship to the Language of Reading Textbooks and the Quality of Reading of Selected Children, Bulletin of the School of Education, XXXVIII, No. 4; Indiana University (Bloomington, Indiana: Bureau of Educational Studies and Testing, 1962), p. 106.

² Guy L. Bond and Miles A. Tinker, Reading Difficulties: Their Diagnosis and Correction (New York: Appleton-Century-Crofts, 1957), pp. 140-166.

For logical comprehension in reading (if this may be distinguished from the experiential, emotional and linguistic contributions of the reader) the simple, early, emerging classificatory abilities have been identified by Piaget. These classificatory abilities are class inclusion, additive and multiplicative class relations, seriation, and certain associated logical operations such as negation, implication, deduction and induction. This logic of classes and relations, as it gradually develops, may be applied to the understanding of relations in simple basic sentences and to relations expressed by embedding sentences and by conjoining them. This logic is also sufficient in most instances for the analysis of the whole of a discourse. It allows for such operations as finding the main theme, the universe of discourse; providing an hierarchical or other organization for the material of the discourse; considering the point of view of the writer (at least as distinct from one's own); and relating his communication to a more inclusive but relevant area of discourse. For reading comprehension during the period of elementary schooling there is the possibility, therefore, of an extensive application of the logic of classes and relations to the reading process.

But the objective in relating logical operations to reading is not simply that the child should comprehend what he has read. The objective is through reading activities to further the logical development of the child. It is a matter of some urgency that a child achieve an implicative orientation in his thinking. Implicative thinking is based on a prior knowledge of classes and relations. It also requires that the child learn to operate on the basis of the data as given rather

than from the more primitive point of view which ignores the given or attends only to specific empirical aspects. It appears to be a matter for investigation to determine the contribution which reading may make to this critical logical development.

Piaget's investigations of early logical operations describe the structures which become available in appropriate circumstances during the elementary school years. But his research also provides some challenging explanations of the difficulties experienced by the school in achieving these quite modest objectives for the child's logical development and for his reading comprehension. In the first place, Piaget's studies demonstrate the unexpected complexity of the "familiar" experiences the child is generally assumed to "understand".³ His studies also make clear the degree of immaturity of early mental operations, the firmness with which young children reject the implicative step in thinking while admitting the objective arguments on which such a step is based (as in concepts of conservation).⁴

Piaget has shown that the logic which it is possible for the child to acquire during the elementary school years is an important segment of the logic of classes and relations. Associated with this early logic is the possibility of interesting deductive and investigative operations. While these logical operations are temporarily limited, they are nevertheless fundamental in all later intelligent behavior. It is

³ Jean Piaget, (1927), The Child's Conception of Physical Causality (New Jersey: Littlefield, Adams and Company, 1960).

⁴ Jean Piaget, (1941), The Child's Conception of Number (London: Routledge and Kegan Paul, 1961).

important therefore to consider the reciprocal aspects of the relationship between reading and logic and in particular to determine the role of reading in the optimal development of logical thinking.

PURPOSE OF THE STUDY

The purpose of this study is to examine the relationships between the logic of the elementary school years and the reading process. This problem will be studied in relation to the investigations of Piaget and his colleagues concerning the origins and early developmental sequences in logical thinking. The problem will also be considered in relation to recent research in the grammar and logic of the language. It will then be possible to discuss the implications of these studies for the improvement of reading comprehension and for the more effective acquisition of the logic appropriate to this period of childhood. On the basis of this investigation criteria will be proposed for selecting reading materials and evaluating instructional procedures in relation both to comprehension and to the need for a logic of classes and relations sufficiently powerful to effect a breakthrough to formal reasoning at the end of childhood.

LIMITATIONS OF THE STUDY

The study of the relation of Piaget's conception of logical development to comprehension in reading is limited by a number of important considerations.

Almost all of Piaget's extensive research which is presently available in English translation is directly or indirectly concerned with the logical (cognitive) development of the child from birth to adolescence.

This study considers Piaget's investigations of the development which occurs during the elementary school years. Within this period, it considers the development which is characterized by the replacement of early primitive concepts, the construction of logical classes and relations, and the emergence of an implicative attitude.

The development of concepts of quantity, space, time, speed, probability - these and other basic reorientations also investigated by Piaget, and essential for comprehension in reading, are not included in this study.

The consideration of comprehension in reading is similarly limited to the elementary school years (6-12 years). It is, in addition, limited to one aspect of comprehension, namely, that which is dependent on logical operations.

SIGNIFICANCE OF THE STUDY

The logic of classes and relations, which Piaget has shown is the achievement of the elementary school years, is the necessary foundation for the more abstract and more powerful logic of the adolescent and later years. Other forms of abstract logical thinking proceed on the basis of the data which the logic of classes provides.

It will require the efforts of many people to increase significantly the contribution which reading instruction may make to this ongoing process. A start may be made by re-examining the learning process in reading in relation to Piaget's observations and theoretical interpretations of the behavior of the child as he progresses from intuitive

thinking, to concrete logical thinking, and to the greater possibilities inherent in the more abstract reasoning of the adolescent.

AN OVERVIEW

Two themes will be developed in this study. The first is the importance of logical development for comprehension in reading. The second is the role of reading in assisting the child to construct his intelligence. It is necessary however to inquire at the beginning what program the child himself has underway before reading is introduced, that is, the procedures the child has already adopted in an effort to achieve his own emancipation.

Chapter II will present an account of Piaget's methods of investigating the early logical behavior of the child. It will identify the conditions which Piaget finds are already effective in constructing intelligence at the beginning of the concrete period. The significant conditions include:

1. The confrontation of peers.
2. Action-on-objects accompanied by representation in images and symbolic encoding.
3. The circumstance of two contrasting patterns of learning - patterns which continue to be operative throughout the concrete period - namely, substitution and filiation.

Chapter III will consider the basic intellectual reorientations which Piaget considers to be essential for further cognitive advance and for the mastery of early logical operations. These reorientations include:

1. The replacement of primitive ego-centered notions of the world and of causality.
2. The acquisition of concepts of invariance, that is, the recognition that certain properties of objects are conserved in the presence of observed change of form.

New instructional uses for abstract signs in relation to these reorientations will be proposed.

Chapter IV will examine the development of classification - of the ability to manipulate class inclusion relations, to understand the quantity terms "some" and "all" and to develop the hierarchical class structure. Social interaction, the experience of communication, is found to have a unique relationship to these developments. It is also the case that instructional material may have an hierarchical structure. The reconstitution of this structure from the printed communication appears to contribute to the logical development of the child.

Chapter V will discuss a parallel development in logical thinking: the acquisition of multiplicative classification, and the realization of the matrix structure. The embedding of a multiplicative class in a base sentence produces a derived sentence of considerable grammatical complexity. The organization of a discourse as a whole may also have the matrix form. Logical thinking and comprehension in reading will be likely to benefit from a recognition of these organizational and grammatical structures.

Chapter VI begins with an account of the development of logical relations including the relation of simple multiplication of classes

(class intersection). The significance of the construction of intersecting (overlapping) classes for the understanding of conjunction, disjunction and negation is discussed. Piaget's account of the application of the logical operations of conjunction, disjunction and serial ordering to the solution of practical problems is then presented. The implications of a number of experiments designed to teach logical concepts to children are considered.

Chapter VII discusses a number of experimental approaches combining recent advances in our knowledge of logical development, of grammatical structure and of reading. A reasonable objective for such a co-operative research effort is considered to be the reduction of cultural lag in the acquisition of the concepts and behavior fundamental to logical thinking.

CHAPTER II.

SOME CHARACTERISTICS OF PIAGET'S INVESTIGATIONS OF LOGICAL DEVELOPMENT

METHODS OF STUDYING CHILDREN

Piaget's methods of studying the development of logical thinking in children are related to his general concept of how this process occurs. He considers the child to be an active as contrasted with a reactive personality; to be an "open" system conducting transactions with the environment. Over the period of childhood, and by regular sequences, exchanges with the environment effect remarkable advances in cognitive organization. As an active agent in mutual interaction within a complex "whole," the child assimilates and accommodates in his exchanges with the environment and in this way constructs his intelligence.¹

Piaget undertakes to observe this "system-in-action." The behavior he observes is recorded in the thousands of protocols of children throughout his work. The behavior may be verbal, motor, manipulative or motor-pictorial, or any combination of these. The data are obtained by the following procedures:

1. Verbal responses which are elicited by a succession of verbal stimuli, provide most of the data in Piaget's

¹ Jean Piaget, (1936), The Origins of Intelligence in Children (New York: Norton, 1963), pp. 407-419.

earlier work and this procedure continues to provide data in his later investigations. The examiner will ask, for instance, "Where is the name of the sun?" and he will then frame a second question to probe the meaning to the child of his response to the first question.²

2. Verbal responses may, however, be elicited in response to a demonstration by the examiner which is accompanied and followed by questions. The examiner, for example, pours water from one beaker to another of different height or width and asks, "Is there the same amount of water or more or less?"³ Small houses are placed in various locations on the "green grass of a pasture." A question will be, "Is there the same amount of grass for the cows to eat or more or less?"⁴ The child observes and reports and is asked to justify his conclusions.

3. Motor-manipulative behavior by the child himself, accompanied and followed by the probing questions of the examiner is an increasingly important clinical-like procedure in Piaget's studies. "Put out as many egg

² Jean Piaget, (1927), The Child's Conception of the World (London: Routledge and Kegan Paul, 1951), p. 78.

³ Jean Piaget, (1941), The Child's Conception of Number (London: Routledge and Kegan Paul, 1960), pp. 17-19.

⁴ Jean Piaget, (1948), The Child's Conception of Geometry (London: Routledge and Kegan Paul, 1960), pp. 262-264.

cups as there are eggs." The child then considers the number of egg cups no longer visually in a one-to-one relationship with the eggs but spread out in a longer line or assembled in a heap. The examiner asks, "Are there more egg cups or the same number or fewer?"⁵ This test examines the child's ability to conserve discontinuous quantity. Again, the child may be asked to build a tower of blocks "the same height as this one." The examiner records the child's behavior in a series of protocols in order to study the development of the concept of a unit in measurement.⁶ In another experiment, the child is instructed to "put together what belongs together," when he is given a collection of counters of different shapes, colors and sizes. His behavior is analyzed to determine the sequences in the acquisition of the ability to classify. The child is asked such questions as, "Are all the circles blue?" to investigate the processes by which the quantification of classes is mastered by the child.⁷

⁵ Jean Piaget, The Child's Conception of Number, op.cit., pp. 50-56.

⁶ Jean Piaget, The Child's Conception of Geometry, op.cit., pp. 27-66

⁷ Bärbel Inhelder and Jean Piaget, (1959), The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1964), pp.100-110.

4. Motor-pictorial responses are used extensively in in Piaget's study of the child's conception of geometry⁸ and of space.⁹ The experimenter obtains a series of drawings by children of various ages which he analyzes to determine the sequences by which the ability to conceptualize space is acquired. For instance, the child is asked to represent the developed surfaces of such objects as cones, cubes, cylinders, pyramids. He is asked to imagine and draw a surface obtained by slicing through these objects at various angles. Piaget finds that the young child is unable to represent such surfaces before he has actually unfolded the objects or has cut through such a form.¹⁰

It is clear that a complex theory of the nature of cognitive development and a wide range of hypotheses concerning the areas of behavior in which significant cognitive changes occur, inform the choice of these procedures in examining children. There has been a trend in Piaget's later work toward greater reliance on the evidence provided by the children's actions, less upon verbal reports. Both, however, are recorded and analyzed. Inferences regarding the nature and sequences of cognitive development are based on analyses of the data provided by these protocols.

⁸ Jean Piaget, The Child's Conception of Geometry, op.cit.

⁹ Jean Piaget, (1948), The Child's Conception of Space (London: Routledge and Kegan Paul, 1956).

¹⁰ Ibid., pp. 247-297.

SOME GENERAL PROPOSITIONS CONCERNING
THE NATURE OF LOGICAL DEVELOPMENT

1. Interaction with peers is a catalyst of cognitive change.

It is Piaget's opinion that the primitive cognitive structures of early childhood evolve in circumstances of vivid confrontation with peers.¹¹ Confronting has recently been defined by Anderson as "a situation in which the behavior or presence of one organism makes a difference in the behavior of another ... confronting is not 'conflicting'; it represents a free interplay of differences, a spontaneous abandoning"¹² Piaget, however, admits clash and conflict into the confrontation of children and observes that such confrontation is a necessary catalyst of desirable social and intellectual change.¹³ The child, he states, has been misinformed of the nature of his environment as a result of his early centering on privileged elements in perception. He has proceeded on the basis of a single point of view (his own) which operates in one direction (from himself). This "egocentrism" and "irreversibility" characteristic of early orientation yields, however, as the child is challenged by other viewpoints in communicating with peers.¹⁴

¹¹ Jean Piaget, (1947), The Psychology of Intelligence (London: Routledge and Kegan Paul, 1959), pp. 156-163.

¹² Harold H. Anderson, "Personality Growth: Conceptual Considerations," Perspectives in Personality Theory, ed. H.P. David and H. Von Brachen (New York: Appleton-Century-Crofts, 1957), pp. 131-158.

¹³ Jean Piaget, (1926), The Language and Thought of the Child (London: Routledge and Kegan Paul, 1962), p. 55.

¹⁴ Jean Piaget, (1928), Judgment and Reasoning in the Child (London: Routledge and Kegan Paul, 1962), p. 245.

2. Action on objects is the child's most important method of learning during his early years. Actions are accompanied and followed by representation and symbolic encoding.

Given the circumstances of confrontation, the child learns by means of direct manipulative contact with an appropriate "nutritive" environment, that is, by performing actions on objects. But having completed the action (unfolded the cube) he also becomes capable of a short-circuiting procedure. He may begin the action but halt it. For he now has available an image or a mental representation of his earlier action. It functions as a "set of instructions" or a "plan" for directing current operations. The plan at the beginning is at the level of a symbolic image, a picture, a feel for what he intends to do. As his language develops, he will encode some of these plans in the form of verbal instructions. It is then possible to develop the ability to state relationships which hold among these objects and actions.¹⁵

Bruner has named these sequences in cognitive behavior the "enactive", the "ikonic" and the "symbolic."¹⁶ He suggests that these sequences continue to be useful and appropriate for learning in various circumstances throughout adult life.

While Piaget stresses that it is the child's own actions which initiate change, nevertheless the adult may contribute signi-

¹⁵ Jean Piaget, (1945), Play, Dreams and Imitation in Childhood (London: Routledge and Kegan Paul, 1962), pp. 241-244.

¹⁶ Jerome S. Bruner, "The Course of Cognitive Growth," American Psychologist, XIX, No. I (1964), pp. 1-15.

ificantly to the process. He may arrange for confrontation and provide a stimulating material environment; he may also induce "liberated convictions" in the child by well-framed and well-timed questions and comments.

3. Cognitive change may occur both by the replacement of primitive concepts, and by their gradual modification.

Piaget distinguishes two essentially different kinds of transaction between the child and the environment each producing cognitive change during the elementary school years: they are substitution and filiation.¹⁷ Substitution is a process in which subsequent performance replaces antecedent performance with no carry-over of the characteristics of the earlier to the later notions. In substitution the familiar process of change over a period of time, with a succession of developmental stages, is absent. Some overlapping does occur during which the child will affirm each of two mutually exclusive notions. But substitution appears to be relatively sudden and irreversible. It is the process by which the child comes to discriminate between the self and the non-self, between internal and external events, living and non-living, sign and significate. It is the process by which he replaces notions of a magical animistic causality with concepts of mechanical causality, of probability, etc. Filiation, on the other hand, is the familiar process of school learning, and of learning by experience, in which subsequent performance derives from the earlier by a series of gradual steps in a constant chronological order. In filiation, earlier

¹⁷ Jean Piaget, "Transposition du problème de l'analytique en termes génétiques," Etudes d'épistémologie génétique. IV. Les liaisons analytiques et synthétiques dans les comportements du sujet, eds. L. Apostel, W. Mays, A. Morf, and Jean Piaget (Paris: Presses Universitaires de France, 1957), pp. 41-85.

and later behavior are related in kind and one is the outcome of the other. A sequential and dependent relationship exists between prior and post performances. Substitution, in the circumstances of our present limited knowledge of the process appears to be almost entirely subject to maturational influences and factors of confrontation and incidental experience. Demonstration, telling, are relatively ineffective in inducing these changes. Piaget states, "No direct experiment can possibly lead the child to the discovery that a movement [e.g., of the clouds] is not purposive, or that an activity [a stone rolling toward a person] is not conscious." The modification of such a conviction, he points out,

does not arise from a wider knowledge nor from a developed ability to control circumstances, nor from experimentation ... it can result only from his becoming progressively aware of his self and his own thought ... from the growth of consciousness of self.

It is only, he concludes,

from experiences of a social or inter-individual type ... that the mind forms such improbable conceptions as movement without consciousness or existence without awareness.¹⁸

Laurendeau and Pinard conclude that to the young child an equally improbable concept is that an event should have a mechanical rather than a purposive or anthropomorphic explanation.¹⁹ Substitution (the replacement of primitive concepts), continues to be an important

¹⁸ Jean Piaget, The Child's Conception of the World, op.cit., pp. 238-240.

Monique Laurendeau and Adrien Pinard, Causal Thinking in the Child (Montreal: Institute of Psychological Research, 1962), pp. 37-44.

process in cognitive development up to the last year or two of elementary schooling. Piaget suggests that changes effected by substitution "underwrite" the developments achieved by filiation during this period.

INTERRELATED AREAS IN EARLY LOGICAL DEVELOPMENT:

CONCEPTS, CLASSES, RELATIONS

Three interrelated areas in the logical development of the child may be identified for further study.

1. The area of concept development. This area is associated with sensori-motor and social experience. It includes action on objects and interaction with peers and adults during which the child gradually internalizes and symbolizes his actions and develops concepts of himself and of the nature of the objects he experiences in his environment (for instance, as living or non-living, as having properties which are conserved, etc.).
2. The area of logical analysis and classification. This is the activity by which the child comes to conceive of objects as members of a class and of classes and sub-classes as related in various ways. These may be related as hierarchical structures; serially and in serial correspondence; as matrix structures; in simple intersection; and as over-lapping classes.
3. The area of the development of relations. These are relations within statements and relations between

statements. They include causal, spatial, temporal relations and implicative relations.

Each of these areas in logical and cognitive development have been studied by Piaget. They will now be examined and their relations and implications for the teaching of reading will be considered.

CHAPTER III.

CONCEPT DEVELOPMENT

INTRODUCTION

It would seem reasonable to expect that introducing the child to reading and writing, both second level symbolic processes, would induce a dramatic leap forward in logical and cognitive development comparable to the progress which Luria has shown accompanies the child's earlier acquisition of spoken language.¹ Piaget's investigations suggest, however, that this is not the case, that cognitive change during the elementary school years is slow and hardly won. Progress achieved in one area (for instance, conservation of continuous quantity) must be achieved again by similar stages for each new application of the principle (for instance, to size, weight, length, area, etc.). These findings have been confirmed in recent studies, notably those of Smedslund.² Laurendeau and Pinard in a recent study of Canadian children also find that primitive conceptions of the world and of causality continue, though they steadily decrease to the age of 10-11 years.³

¹ A. R. Luria, "The Development of the Regulatory Role of Speech," The Cognitive Processes: Readings, ed. R. J. C. Harper, et al. (New Jersey: Prentice-Hall, 1964), pp. 601-622.

² Jan Smedslund, "The Acquisition of Conservation of Substance and Weight in Children, I. Introduction," Scandinavian Journal of Psychology, II (1961), pp. 11-20.

³ Monique Laurendeau and Adrien Pinard, Causal Thinking in the Child (Montreal: Institute of Psychological Research, 1962), p. 252.

It is necessary, in view of these findings, to consider the interrelations of concept development, of logical development and of learning to read. The hypothesis is that there will be conditions characteristic of one which will tend to limit or to inhibit progress in another. There will also be mutually facilitating characteristics. In either case, these relationships will be significant in selecting materials and methods in teaching reading.

One such relation between concept development and language learning appears to connect the child's facility with the spoken language and the meanings he associates with the words and sentences he speaks and reads. Studies of children's language indicate that many children now enter school with an extensive vocabulary and an impressive control of the grammar of the language. It has been suggested that the teaching of reading is not taking full advantage of this situation.⁴ Piaget's studies, however, indicate that there is a further aspect of this condition to be considered. The precise associations which the young child makes with the words he speaks and the relationships he intends to express in his acceptable sentences are likely to differ significantly from those of the adult who speaks the same sentences. They will differ from the child's own interpretations when the process of substitution is relatively complete between 11 and 12 years.

⁴ Ruth G. Strickland, The Language of Elementary School Children: Its Relationship to the Language of Reading Textbooks and the Quality of Reading of Selected Children, Bulletin of the School of Education, XXXVIII, No. 4, Indiana University (Bloomington, Indiana: Bureau of Educational Studies and Testing, 1962), p. 2.

Piaget suggests that these differences between adult and child meanings are pervasive; his research indicates that they will be represented in the early stages of learning to read in the following areas:

1. In notions of the nature and origin of names.
2. In concepts of the nature and location of thinking.
3. In explanations of causality.
4. In concepts of conservation.

PRIMITIVE CONCEPTS AND THEIR REPLACEMENT

1. The Concept of a Name

Primitive notions of names and their origin continue well into the period of learning to decode and interpret printed signs.⁵ These concepts would appear to modify significantly the interpretation of what is read. The child 5 to 7 years who speaks the names "sun," "house," tends to regard these names as a part of the thing, as situated within things, as emanating from the thing named.⁶ The name of the sun is "inside the sun";⁷ it's not in the head "because it's in the sun."⁸ The name of the clouds is "inside them too."⁹ One has but to look at a

⁵ Jean Piaget, (1927), The Child's Conception of the World (London: Routledge and Kegan Paul, 1951), pp. 61-87.

⁶ Ibid., p. 64

⁷ Ibid., p. 72

⁸ Ibid., p. 74

⁹ Ibid., p. 72

house to know it is called house. Similarly, the name of the lake is "on it ... because it isn't in it, ... because there's water there."¹⁰

Between 7 and 8 years the process of dissociating the name from the thing is under way. The name is thought of as in the air, in the sky, in the voice when you say it. It is no longer attached as a label to the object, yet it contains in itself the quality of the object -- the yellow ball which is the sun implies and contains the name "sun"; no other name would be satisfactory. The young child, when he thinks of it, considers that a thing did not exist - it could not have been made - before there was a name for it.¹¹

The final replacement of these notions occurs between 10 and 11 years. A name is then accepted as an arbitrary sign given by man and handed down from father to son. The child agrees that another name could equally well be substituted for the one in current usage. At this point the child will be surprised that you should enquire about his opinion in such an obvious matter. He has forgotten that it was possible - that he himself - once thought otherwise. This is a characteristic response when learning has occurred by substitution, as Piaget defines it, rather than by filiation.¹²

To the extent that oral signs are not cleared of these primitive adherences, the child may be expected to have difficulty in discriminating between the sign and the thing signified in reading. A

¹⁰ Ibid., p. 73.

¹¹ Ibid., p. 64.

¹² Ibid., p. 84.

number of children in beginning reading appear to find the problem particularly confusing in the case of names of people dissociated on the printed page from their "rightful" locations with their owners.

2. The Concept of Thinking

Comprehension in reading may be further affected by the child's early notion of thinking as a material thing, external, and having magical powers.¹³ Tie (10;10) (10 years, 10 months), believes for instance, that thought may have strength, "it depends what you are thinking of ... boxing" But he suddenly realizes his error once he is questioned (an instance of liberated conviction). He adds, "Oh, I was wrong. I was thinking it was the word that hit."¹⁴

But not only words and thinking may have strength and magical powers; for some time inanimate nature retains purposiveness and awareness.¹⁵ Piaget finds that many children assign to a wide range of objects in the environment a degree of conscious life that includes both awareness of their names and some ability to think. Fish and clouds know their names; the moon knows its name because it's alive, it moves (Mart 8;10).¹⁶ Mey (10;0) (advanced) concedes that trees may not know their names, they can't learn things, but they see other trees besides themselves and think they are the same thing.¹⁷

¹³ Ibid., p. 132.

¹⁴ Ibid., p. 59.

¹⁵ Ibid., pp. 171-206.

¹⁶ Ibid., p. 79.

¹⁷ Ibid., p. 80.

The "errors" in these responses could be described as errors in classification. But the problem is a circular one for the child. Classes can not be established until their intensive and extensive properties are recognized and appropriately encoded. (Trees are plants; plants are living things with specific characteristics; trees differ from other plants in specific ways, etc.). But these intensive properties are themselves concepts which are not yet available to the child.

3. Concepts of Causality

The child's conception of physical causality is in part dependent on an accurate prior classification of objects into living and non-living. Before the age of 7-8 years, in his explanation of how an observed action occurred, the child assumes the presence of conscious life, and intention in inanimate objects and he will seldom include a mechanical explanation of their operations.¹⁸

A mechanical explanation involves contact and transference of movement. From 8-11 years, there is an increasing tendency to produce and to defend mechanical explanations. The child uses arguments of "condensation": a stone is heavy from the fact it is close packed (not so that it can make the river flow). The close packing is understood as a reversible process so that one may also argue from "atomistic composition": the stone is made up of grains of earth and can fall apart again under external pressure.¹⁹

¹⁸ Jean Piaget, (1927), The Child's Conception of Physical Causality (New Jersey: Littlefield, Adams, 1960), pp. 115.

¹⁹ Monique Laurendeau and Adrien Pinard, Causal Thinking in the Child (Montreal: Institute of Psychological Research, 1962), pp. 7-15.

Gradually the child extends the area of application of mechanical explanations. For modern children such extensions tend to emerge quite early in relation to toys and bicycles. Once they have achieved a mechanical explanation, children show an ability to make certain logical deductions. In accounting for the actions of a motor, for instance, they will not know precisely how the motor works but they are certain there will exist intermediate conditions which will be found to be the necessary and sufficient explanation of its action.

Yet progress in achieving and extending notions of mechanical causation, Piaget finds, is on the whole neither consistent nor rapid. Primitive beliefs persist in a significant proportion of children throughout the elementary school years.

These findings have recently been confirmed in the series of studies conducted by Laurendeau and Pinard. On the basis of the analysis of the responses of a sample of 500 children, age 4 to 12 years, selected to be representative of the child population of Montreal, they report that "primitive or precausal beliefs are manifested with such frequency that they cannot be regarded as purely individual or accidental."²⁰

An analysis of these responses showed 28.6 percent of the children used realistic explanations in answering questions dealing with the cause of events in their every day experience (dreams were actual occurrences in the room beside them). Animistic terms were used by 64.4 percent and dynamistic terms by 46.6 percent of the children.

²⁰ Ibid., p. 245.

These children were therefore considered to attribute life and consciousness to inanimate objects, or to grant them "an energy similar to man's muscular strength which makes them capable of all sorts of efforts and motions." Two protocols will illustrate first an aniministic, then a dynamistic response:

49 - (7.0) What makes the clouds move?

The moon-it drags them.²¹

28 - (10.0) Where does the wind come from?

From a big man, like the one in our
first grade book.²²

Finalistic and artificialistic terms were used in this study by 69.9 percent and 50.6 percent of the children respectively. Children in the former group explained objects as behaving as they do so as to be of service to man: a ship floats so as to carry people; the night is so we may sleep.

21 - (9.0) Why is it dark at night?

Because we've had a completely
sleepless day and then at night
we must rest.²³

Children, who gave finalistic explanations also posited a maker as cause, in analogy with human industry. Rivers and lakes exist

²¹ Ibid., p. 195.

²² Ibid., p. 198.

²³ Ibid., p. 176.

so that boats may sail on them These children moved next to the arti-
ficialist position that men have "dug rivers and lakes in order to move
about from one place to the next."²⁴

No general system has been found to link these various beliefs.
Laurendeau and Pinard speak of them as "disconcertingly incoherent."²⁵
Piaget also refers to the persistence of these beliefs. He notes that
causal thinking achieved in one content area remains isolated for some
time from other areas. He concludes that, "until there is a general
replacement for a notion such as artificialism, the child can only ex-
plain things by having recourse to human activity and not to the things
themselves."²⁶

Nevertheless by 12 years most children speak as adults in
these matters.

48 - (12.0) Why is it dark at night?

Because the earth turns on itself,
then this produces the day and night.

What makes it night?

It comes from the absence of the sun,²⁷ etc.

The protocols quoted above are from the University of
Montreal study. They represent the concepts of causality of Canadian

²⁴ Jean Piaget, The Child's Conception of the World, op.cit.,
p. 329.

²⁵ Monique Laurendeau and Adrien Pinard, op.cit., p. 13.

²⁶ Jean Piaget, The Child's Conception of the World, op.cit.,
p. 313.

²⁷ Monique Laurendeau and Adrien Pinard, op. cit., p. 178

children 5-12 years, 1962. They are indistinguishable from the protocols of Swiss children of the same age, 1928. The concepts and private explanations of many of these children as they read of the sun and wind, rain and clouds, lakes and rivers, the moon, night and day, transportation, trees and animals, are primitive to a degree that is likely to make them inaccessible to the adult who is teaching the children. The teacher is unlikely to credit the children with these notions. Even if the children revealed them, she would have difficulty in knowing how to treat the problem with our present limited knowledge of the process of substitution. The children may realize this. If they do, their skill in suppressing these notions in the context of the reading lesson deserves some commendation. They will have learned to appreciate the difficulties - and the risks - inherent in communication.

Research extending from 1926 to 1964 suggests that the school and the culture have continued to function throughout this period at about the same level in inducing the kind of cognitive change which involves the little understood process of substitution. Research attention has been concentrated on the kind of learning which proceeds by filiation. Yet learning by filiation is predicated on the earlier abandoning and replacing of primitive orientations. Properties of objects and the relations between objects, cannot be discussed intelligently in the context of animistic and artificialistic notions. It is a question whether the six school years required to complete the substitution process may be in part an artifact of cultural and

educational practices. It would seem to be no more difficult for the child to operate from a scientific than from a precausal position - the one is no more complex than the other. The crucial matter is the shift itself, its timing and scope.

THE ACQUISITION OF CONCEPTS OF CONSERVATION

Children below a certain age are unaware of the conservation (invariance) of certain properties of objects in the presence of perceptual change. They frequently indicate that they have the "facts" needed for arriving at such a conclusion: that nothing has been added and nothing taken away; that if you pour it back it will be the same amount of water. But they do not consider that these arguments are relevant to the distorted condition. Instead they credit the visual appearance of change.²⁸ They also trust a visual comparison for measuring accurately - and it is indeed shrewd. For instance, between the age of 5 and 7, in judging the height of two towers of blocks, they decide on the basis of what they "see."

Lou (6;6) says, They're the same.

How do you know?

I've seen.²⁹

Similarly two "roads," it will be agreed, are the same length when observed parallel to one another. If one is made to zigzag, the change they "see" is now also a change in length. A "potato patch"

²⁸ Jan Smedslund, op. cit., p. 14.

²⁹ Jean Piaget, (1948), The Child's Conception of Geometry (London: Routledge and Kegan Paul, 1960), p. 46.

divided into pieces is no longer a potato patch having the same area as before. Two rows of beads in a visual one-to-one relation are the same number when their positions are in correspondence. There are more (or fewer) beads in the row that is spread out.³⁰

Judgment in these instances is based on perception and the implicative step based on the logic of the situation is steadfastly resisted. It is this implicative step, which involves processing the logical argument, that in Smedlund's opinion is "really the crucial problem." "Why," he asks, "does this argument suddenly become relevant and lead to the idea that conservation is logically necessary?" How do children "acquire conservation against the perceptual appearance of things?"³¹

Such learning is not limited to childhood. New areas of applicability of the principle of invariance in the presence of apparent change continue to be understood and discovered in adult life. But the fundamental invariances required for early logical processes in thinking and for a scientific orientation to the environment are acquired during childhood - from about 5-1/2 to 11-12 years. They have also been shown to be acquired in a regular sequence: conservation of discontinuous substances, before conservation of continuous substances, conservation of weight, length, distance, before conservation of volume. Conservation of volume appears only after the age of 12.

³⁰ Jean Piaget, (1941), The Child's Conception of Number (London: Routledge and Kegan Paul, 1961), p. 79.

³¹ Jan Smedslund, op. cit., p. 14.

In addition to inability to take the implicative step, Piaget explains the difficulty in achieving basic concepts of conservation as an original inability to attend to more than one perceptual feature at a time, so that the fact of their compensating one another escapes notice. Progress occurs as the child begins to shift his attention from one of the extremes (height) to the other (thinness) and as this shifting gradually speeds up. For some time, however, the necessary effort in "holding" both perceptions so that they may be compared is not accepted by the child.³²

A study by Smedslund presents some evidence that if stress is introduced by making the problem more complex and if an attempt is made to avoid situations in which incorrect responses based on perception provide quick and premature satisfaction to the child, his behavior may be seen to change and the outcome is different. Smedslund's hypothesis is that cognitive conflict may be the effective factor in inducing "a cognitive reorganization which results in the concepts of conservation."³³

Some degree of conflict is already introduced when the child is being questioned even in a relatively straight-forward situation. "Do you think this one weighs more than, the same as, or less than that one?" Even in this situation the child shows signs of hesitation, "looking back and forth," "signs of uneasiness

³² Jean Piaget, (1947), The Psychology of Intelligence (London: Routledge and Kegan Paul, 1959), p. 121.

³³ Jan Smedslund, "The Acquisition of Conservation of Substance and Weight in Children V. Practice in Conflict Situations without External Reinforcements," Scandinavian Journal of Psychology, II (1961), pp. 156-160.

and tension." But this degree or kind of stress is notably ineffective in inducing change. It has also been shown that demonstration, for instance using balance scales, is ineffective.³⁴ While conservation may be temporarily accepted in these circumstances, it is not a firm commitment. It may be extinguished by counter suggestion, as Smedslund has demonstrated.

In the final experiment in this series Smedslund makes use of a form of cognitive conflict which he suggests may prove to be a more effective catalyst of change. He states that his experimental conditions eliminated the possibility that the change was effected by external reinforcement. "A completely neutral and indifferent attitude toward all responses was maintained," he states. Reinforcement is, however, a subtle matter and replications of this study may be indicated to confirm or infirm Smedslund's conclusions. The conflict situation, as developed in Smedslund's experiments, is, however, a significant departure.

Smedslund's procedure was as follows.³⁵ He deformed object A, one of two balls of plasticine of equal size, into a sausage. If the child judged this would make it lighter in weight, in plain view of the child he removed a piece from object B making it lighter too. The decision is now more complicated - which change made the greater difference? Addition-subtraction of material is combined

³⁴ Ibid., p. 157.

³⁵ Jan Smedslund, op.cit., VI. "Practice on Continuous versus Discontinuous Material in Conflict Situations without External Reinforcement," Scandinavian Journal of Psychology II (1961), p. 204.

in various ways with deformation. Progress is indicated by adherence to the more straight-forward evidence provided by addition-subtraction and the consequent ignoring of the deformations. The initial tension (stress) is reported to disappear, after which one or other of the schemas is consistently followed.

The conclusion suggested by the experiment is that a situation which is more complex, presenting a conflict between incompatible schemata or some other kind of conflict, may be more effective in inducing conservation than demonstration or questioning in simpler, and to the child, more easily resolved situations. The explanation offered is that in order to reduce an uncertainty which disturbs and challenges, the child "tries and frequently finds the solution to the problem."³⁶ As Donaldson puts it, he "struggles" with the data.³⁷

When the child "knows" he again offers the statement which was clear to him before, "You didn't add anything and you didn't take anything away." It is now offered as relevant; the implication is accepted. Piaget points out that this conclusion, as the child now presents it, is a logical inference, "not derived from the properties of the external world."

The acquisition of the fundamental notions of conservation occupies the child for a total period covering the elementary

³⁶ Jan Smedslund, op.cit., p. 157.

³⁷ Margaret Donaldson, A Study of Children's Thinking (London: Tavistock Publications, 1963), p. 203.

school years. The same period of time is required for a clear transition to notions of mechanical causality. Childhood is a long period in human development; the question is, is it longer than is necessary and desirable.

SOME RELATIONS BETWEEN PRIMITIVE CONCEPT REPLACEMENT AND THE DEVELOPMENT OF LOGICAL THINKING

Gray,³⁸ in his UNESCO report, clearly pointed to the limited value of learning to "read" when a common social significance could not be attached to the signs decoded by the reader. Piaget has added that the common significance which it is possible for the reader to assign is directly related to the logical structures currently available to him, and the level of his concept development. He has shown that during childhood logical structures evolve in a regular sequence associated with the replacement of primitive concepts. For instance, during the early concrete period the child comes to speak of a name as an arbitrary sign; he begins to discriminate between events which are internal and external; he accepts thinking as internal, non-material and conducted from a number of points of view with varying results. These achievements in turn make possible the shift from a motivational to a mechanical model for explaining the behavior of objects. This again in turn facilitates one of the next major developments - the recognition of the invariance of specific properties of objects in the presence of certain perceptual changes

³⁸ William Scott Gray, The Teaching of Reading and Writing, an International Survey (Paris: UNESCO, 1956).

in form. The child is constructing the concepts which enable him to communicate with his society.

Piaget considers that in each of these changes the child is modifying his primitive behavior by means of well-established patterns of learning. This learning is stimulated by confrontation with peers and by the demands and rewards of communication. The basic data, the raw material for cognitive advance is accumulated by direct action on objects. When this action is represented or imaged, the child is able to evoke objects and actions in their absence. He can, for example, not only recognize a triangle but he can compare the figure before him with a large number of comparable shapes not now present to perception; and having cut through the pyramid, he can imagine the action and the result of the action before it is performed. One child, who still needed to carry through the action, interpreted the need for action prior to imaging it, in this way:

Sul (5;11) You can think now because it's been cut.³⁹

Sul will later be able to anticipate the action for, as he puts it, he can "think now." Thinking, mental operations, in Piaget's view, can only replace action on the basis of the data action itself provides.

But thinking, he agrees, adds a new dimension to the data of action when the child adopts an implicative or an explanatory posture vis-a-vis his actions. He adopts an implicative attitude in

³⁹ Jean Piaget, (1948), The Child's Conception of Space (London: Routledge and Kegan Paul, 1960), p. 252.

the acquisition of concepts of conservation. He also relates actions to thinking as he explains his actions. He decides "this triangle will make a good roof"; and he observes that "roofs are this shape so the rain can run off." Causal relations and implicative relations are arrived at in thinking by placing into relationship (*mise-en-relation*) his own activities.⁴⁰ These relations and implications, his images, and the actions on which all of these are based, are continuously open to a check for accuracy by returning to the basic data, to concrete experience.

These are then the child's proven means of progress. If they fail, the child, on his own, has no other means of escaping from the social isolation imposed by primitive animistic notions. The withdrawal behavior characteristic of the timid isolated child, may therefore have a cognitive no less than an emotional etiology.

IMPLICATIONS OF CONCEPT DEVELOPMENT

FOR COMPREHENSION IN READING

When he is introduced to reading, the child finds many of the long-practised, dependable and rewarding sequences of learning of his earlier years considerably altered. Indeed he is presented with an almost new situation. Direct motor exchanges with the environment are reduced: the "information" has already been encoded in signs which the child perceives as objects in space but does not alter or manipulate as he reads. The point of departure for the child is therefore the sign and not the action (however carefully

⁴⁰ Jan Smedslund, op.cit., p. 13.

he has been prepared for this moment of reckoning). Step one in reading is to decode the printed signs and reproduce them in verbal signs, his oral language. Step two is to image the action as he is speaking about it. At step three he undertakes to encode the images in propositions of his own formulation (to say what it means). While step three is in progress he may find it necessary to remodel his original image. The check for accuracy available to him is now also a new procedure. It requires a return to the printed page for a second decoding and the recall and editing of relevant experience.

This return is notably rejected by children. Donaldson in A Study of Children's Thinking reports the frequency with which children abandon loyalty to the given (in this case the return to the printed page) and wander away from the information presented there to recount apparently unrelated experiences.⁴¹ Children appear to find this step (and other steps as well in this new learning sequence) confusing, and they omit or modify one or more of them. Because of the newness of the whole, each step in this alternative learning sequence must be acquired as a separate and distinct operation. The sequencing itself must also be remembered as part of the task of learning to read.

An intermediate form of this learning sequence is familiar to children who have heard stories read or told. In this case, the speaker's voice with its appropriate stress, intonation, juncture, and accompanied by gesture, precedes and stimulates the production

⁴¹ Margaret Donaldson, op.cit., p. 66.

of the image and of the orally encoded or motor response. In reading, however, the child himself operates the total system and he must be prepared to conduct the process in the absence of the prior stimulus of the spoken word.

Reading, therefore, appears to be a new form of interchange of information with the environment requiring dramatic modifications in the child's familiar cognizing operations. It would seem to be desirable to arrange for a greater measure of continuity between the child's earlier learning patterns and the new sequences introduced as he begins to read.

For a possible modification of the time-lag which occurs in the final replacement of primitive concepts, consideration may need to be given to the effectiveness, demonstrated experimentally, of inducing logical (implicative) behavior under the following conditions:

1. Inducing cognitive stress by making the learning situation complex and challenging rather than simple and without urgency.
2. Putting the child's new technological skill in reading to work directly on the problem of eliminating these primitive notions.

For this purpose, the sequence of learning familiar to the child should be retained: manipulation, representation in images, symbolization, then the check by a return to the data. The ideas encoded would be the child's ideas, at whatever level of maturity they presented themselves.

The intention would be to test the effectiveness of having the child encode in printed symbols his first intuitive notions of conservation and other properties of objects, of causality, of the nature of sign and significate.

The acquisition of scientifically based concepts in each of these areas, Piaget maintains, is an important event in cognitive development. Taken together they enable the child to proceed in the construction of his intelligence. Once acquired they function as cognitive tools in all later exchanges with the environment.

The importance or effectiveness of encoding these emerging concepts in printed signs Piaget does not discuss. He appears to consider the rate of acquisition of these various concepts as he has observed it to be the normal, perhaps the optimum rate. It is also the case that Piaget has observed these developments in children who, as far as we know, were reading. Thus reading as an occupation and achievement cannot in itself, at the present time, be counted on as a sufficient condition for modifying the rate of acquisition of these fundamental orientations.

The current use of printed signs in teaching reading may not, however, in view of Smedslund's and Bruner's work, and Piaget's account of cognitive development, represent a full exploiting of the potentiality of print. Abstract signs have been shown to have considerable power for inducing, supporting and even accelerating major cognitive reorganization. Support, in particular, may be a critical factor at the concrete level. For while the initial thrust for logical reorganization occurs with the abandoning of primitive

animistic notions and with the acquisition of concepts of the invariant properties of objects, there is much more to be accomplished. Over several years the construction of intelligence proceeds on the basis of the control of the logic of classes and relations. In this process the mastery of the grammatical structures of the sentences by which such classes and relations are expressed is indispensable, not only the structures which occur in the spoken form of the language but also the structures which appear in the frequently more complex sentences of print.

SUMMARY

We have considered some aspects of Piaget's account of the child's pursuit of explanation and prediction as he observes and manipulates objects and records his theories and experiences in spoken signs and images. Piaget finds that these operations during the early concrete period lead to the discovery of dichotomies in three important spheres of confrontation. The child discovers that:

1. There is a mechanical as well as a purposive explanation of causation. Intention, will, purpose may be considered as a cause only in relation to human activities; it is inappropriate in explaining natural and physical phenomena. The teleological elements in thinking are gradually superseded by a deterministic causality.

2. Invariance as well as variance is a property of objects; perception alone is unreliable in determining the invariance of specific properties of objects.

3. There are two contrasting postures vis-a-vis events. One may accept as evidence what one "sees" (the perceptual or empirical posture). Or one may accept as evidence the results of thinking (the implicative or deductive posture).

Some of these discoveries occur as intuitive "preconscious" substitutions replacing earlier notions. Others occur gradually, in a sequence of stages and forms, in which each stage is a necessary precursor of the succeeding stage, that is by filiation.

In filiation a pattern of learning is early established and practised which proceeds from action to imaging, to encoding, to deducing relations, to checking these by further actions. Procedures which make use of the learning sequences familiar to the child and in which encoding in abstract signs is the culminating point of "knowing" have been demonstrated to be effective in certain situations involving concept change.⁴²

⁴² Jerome S. Bruner, "Some Theorems on Instruction Illustrated with Reference to Mathematics," Theories of Learning and Instruction, Sixty-third Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1964), pp. 306-335.

The use of printed symbols to summarize, organize and record the concepts the child "knows" at a particular time may be useful in emancipating the child from early primitive concepts. The replacement of primitive concepts is a necessary condition for the emergence of logical thinking and for comprehension in reading. Primitive "adherences" affecting the child's notions of his environment continue to be present through the elementary school years, and are only moderately influenced by learning to read.⁴³ Complexity rather than simplicity, confronting situations which offer no ready solution, have been shown to mobilize effort and attention in order to resolve the uncertainty. Concepts of conservation acquired in this way resist extinction.

Piaget has shown that when the child accepts the object as that which objects, which insists on its own rights, regardless of his wishes, which has properties and makes claims on him, he becomes open to new dimensions in confrontation. He is observed to respond by developing some powerful techniques for ordering and controlling the new data and avoiding chaos. These techniques include classification and relational and implicative thinking.

⁴³ Jean Piaget, The Child's Conception of Physical Causality, op.cit., p. 244.

CHAPTER IV.

HIERARCHICAL CLASSIFICATION AND ITS RELATION TO COMPREHENSION IN READING

THE ROLE OF LANGUAGE IN THE DEVELOPMENT OF THINKING

The language arts are usually considered to be listening, speaking, reading and writing. Thinking, which requires the manipulation of objects and relations in a symbolic form, is also clearly one of the language arts. No doubt what is intended in the extension is, "listening and thinking," "speaking and thinking," etc. But the inclusiveness of a single term conceals the separateness as well as the interrelatedness of the operations referred to.

A similar oversimplification appears to be involved in some of the linguistically oriented programs for teaching reading. Their authors suggest that since children of 6, 7 and 8 years already control a considerable vocabulary and the grammar of the language, the teaching of reading is a matter of teaching a code until the two are brought into correspondence. What may be overlooked in both instances is the role of language as an instrument of thinking and the need to train children in the techniques of "using" symbols to think. The child may "see and say" and even "remember and say" that $A < B$ and $B < C$ and $A < C$ (where $<$ is read: smaller than, slower than,

nearer than, etc.). But he may not appreciate the logical necessity of $A < C$; that is, that therefore, $A < C$. Clearly either statement is grammatical. What is in contrast here is the grammatical use of symbols versus the grammatical and logical manipulation of symbols. To communicate, it may be sufficient to operate within the rules of the grammar. Beyond this, however, there exists the possibility of logical operations performed by means of the language to achieve new knowledge, to make decisions and to store information efficiently.

An important segment of Piaget's work has been the investigation of the orderly sequences by which the child develops the ability to use the logic of the language to establish and manipulate the logic of classes and relations and eventually the propositional logic of his language as well. The earliest of these abilities to develop appears to be simple classification.

ORIGINS AND DEVELOPMENT OF HIERARCHICAL CLASSIFICATION

1. Sensori-motor Origins

The origins of classificatory behavior (putting together things that belong together) as well as of seriation (putting things in an order) "can be traced to events prior to the evolution of language and symbolic representation." They begin as "actions performed on objects." An infant piles things into heaps and separates them into lots; he nests pots and pans. From these early primitive beginnings classification is mastered in an astonishingly continuous manner. For

its later complex development language and other symbolic systems are necessary since the symbolic handling of objects goes well beyond what can be done in terms of overt behavior.¹

2. Graphic Collections

Pre-classificatory behavior continues well into the elementary school years. During this period it is based on notions of "belonging together." A baby and a cot and baby bath belong together. A mother belongs with these too - put them together and they tell a story. Similar pre-classificatory behavior may be observed in experiments in which the child is given a series of geometric shapes (colored counters) and asked to "put together what belongs together." The child may line up squares - until he comes to a yellow square (for example). Then his criterion changes to color: a yellow circle is placed next to the yellow square, to be followed by blue circles, etc. As he proceeds the child visualizes an object in construction - not a class - and he exclaims, "a train," "a house." Pre-classificatory behavior which culminates in a story or an object, Piaget calls the stage of graphic collections - collections as opposed to classes.² Aspects of this behavior reappear in the language of the school child when he elects to define a word by use: a spade is for digging.

3. Non-graphic Collections

The stage of graphic collections gives way gradually between

¹ Bärbel Inhelder and Jean Piaget, (1959), The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1964), pp. 11-16.

² Ibid., pp. 17-46.

5 and 6 years, as the child begins to construct non-graphic collections which are free of the conditions, "It's a story" or "It's a thing." Zim's protocol represents an intermediate kind of behavior. He is given geometrical shapes and asked to "put the same things together."

Zim (5;9) ... immediately takes the rings one at a time That's a ring; another ring. He piles them all in one lot (with no shape). Then he puts the triangles over the squares and says, That's a house. Finally, he puts all the semi-circles together, calling them "boats."³

Piaget comments, "This yields two non-graphic collections (a 'lot' of rings, and a 'lot' of boats) together with a third collection made up of complex objects"(that is, a graphic collection of houses).

Zim's performance is therefore transitional. He swings from non-graphic to graphic and back again to non-graphic collections.

Non-graphic collections are not yet classes since they depend on spatial proximity to bind the elements to the whole. Zim must point and say, "These are ... and these are ... and over here is a house."

Progress toward classification is represented by the ability to form three or so large "collections," on the basis of trial and error, and to divide these into sub-collections. (Children frequently begin with 10 - 13 collections based on the same material). Juxtaposed groupings such as these invariably precede classification proper.

³ Ibid., p. 52.

Behavior of this kind appears in reading as the child lists the ideas in a paragraph before sequencing or nesting them or relating them hierarchically to a main idea. It is also apparent when two words are linked in meaning simply on the basis of their spatial proximity.

There is a relative discontinuity between this pre-classificatory behavior and the following performance.

Chen (8;6) looks the material over and makes a plan before he begins. Piaget calls this "plan" an "anticipatory schema." Chen constructs three large classes based on the criterion "shape."

The results may be diagrammed as follows:

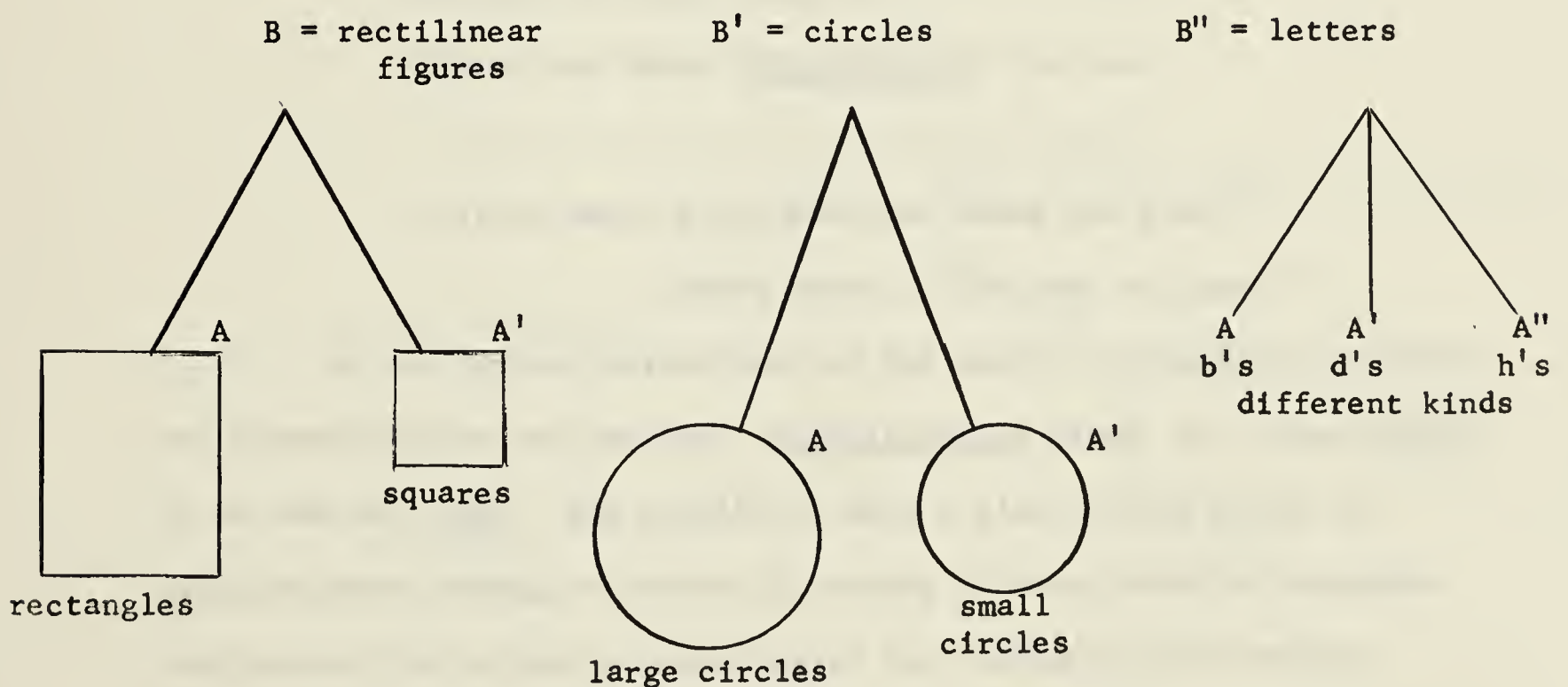


Fig. 1. -- Classification: Criterion Shape, Linear Order

The classes (the B's) are juxtaposed. But in addition to making a plan, Chen appears to have an intuitive grasp of class inclusion, that B is greater than A and includes A ($B \supset A$). There

is no evidence that he is aware of the inverse relation: that
 $A = B - A'$.⁴

The next stage in the construction of classes requires that this inverse operation be understood. It also requires a thorough grasp of the meaning of "all" and "some." Piaget's account of the difficulties which these operations present, will now be examined.

HIERARCHICAL CLASS INCLUSION AND ITS QUANTIFICATION

"Some new Cakes are nice."

"No new Cakes are nice."

"All new Cakes are nice."

"There are three 'Propositions' for you --

.....

Let us begin with 'Some new Cakes are Nice'."

Lewis Carroll, The Game of Logic.⁵

In the earlier collections of the child, the decisive criteria for classification are lacking: quantification (some, all, none) within an over-all plan. The ability to make a plan evolves prior to quantification through a series of groping attacks aided by hindsight, with partial anticipation occurring in the course of the behavior. The plan which emerges is a principle, or a governing criterion for

⁴ Ibid., p. 54.

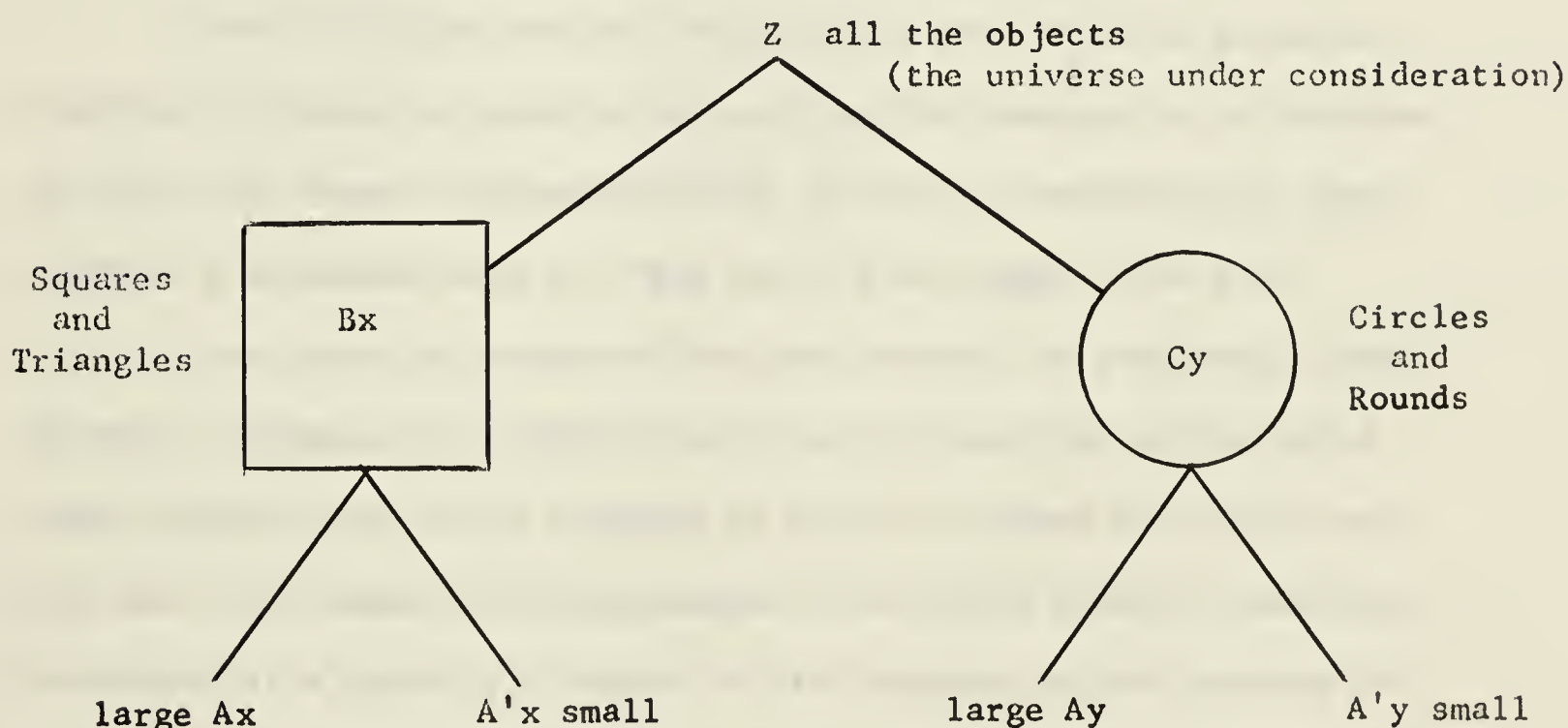
⁵ Lewis Carroll, (pseud.), Mathematical Recreations of Lewis Carroll, Symbolic Logic and The Game of Logic (New York: Dover Publications Inc., 1958).

ordering a given collection. It enables Chen to say, "What I have here are geometrical shapes and other shapes." Rob, working with a variety of geometrical shapes also has this ability.

Rob (8;2) ... after a little experimenting he says,
All the squares and triangles (in one pile) and
all the rounds (in the other). He then subdivides
 these on the basis of size.⁶

Piaget points out that a schema of this kind permits an awareness of "a necessary inverse operation" (the little rounds are all the rounds except the big ones. $A = B - A'$). But the child does not necessarily see the logic of this inverse relation immediately.

Rob's performance may be diagrammed as follows:



x = the property angularity

y = the property roundness

Fig. 2. -- Classification: Criteria Shape and Size, Hierarchical Order

⁶ Bärbel Inhelder and Jean Piaget, op.cit., p. 55.

Rob appears to have realized that together the squares and circles constitute this universe class; that

$$Z = B + C$$

$$B = A + A' \text{ (with property 'x' in common with B)}$$

$$C = A + A' \text{ (with property 'y' in common with C)}$$

Rob's performance is still, however, at the level of collections. The second key problem in the construction of classes remains, the quantification of the relationships in the hierarchical system. This requires three kinds of quantifying operations:

1. All the A's are some of the B's.
2. All the A's are B's and some (but not all) of the B's are A's; therefore, B includes A.
3. $B - A = A'$ (since $A + A' = B$).

One difficulty for the child in the transition to a quantification of classes appears to be learning the meanings to be attached to "all" and "some," and establishing the correct positions of these words in a statement such as, "All the A's are some of the B's."

But there are other difficulties as well in achieving classification. Schemas for classifying are not transmitted to the child ready crystallized in the language of adults. Beyond the words they give him - and these are indispensable - the child himself constructs the notion of a class by a fusion of his language and his actions of grouping. Since a class is an abstraction, one can neither perceive a class nor grasp the concept by knowing the word - not even if all its members should be in full view. What is perceived is the spatial

configuration of the elements. A class is a conceptual judgment arrived at by listing all the members of the class (the extension of the class) and by naming the property shared by every member of the class and no others (the intensional property of the class). One cannot, of course, actually see or list all members of a class widely dispersed in space. One conceives of such a class by denoting and assigning to its members specific properties as a class.

Since a class is a construction, not a perceptual given, there is the possibility that extensive reliance on visual elements for comprehension in school learning may distract the child from the task of classifying which requires mental operations that are not perception-bound. This is a calculated risk in "reading pictures" for meaning, for example. It is necessary that the child realize the considerable difference between noting visually similarities and differences; noting proximity in time and space, when such are suggested by an illustrative picture; noting a visually presented relation between objects - and performing the mental operations required for unambiguous classification. The question takes on added significance in view of Piaget's considered opinion that inability to assign meanings correctly to "all," "some," "one," "none," which is logical operation, is one of the chief factors in maintaining the child's performance at the level of juxtaposed collections and in effectively blocking progress in classification.

What is the child's difficulty with the quantity word "some"? What does "some" mean?

Rus (5;3) says, Some doesn't mean all⁷ -

a bit of negative information quite useful as far as it goes (some birds swim, doesn't mean all birds swim, give me some of the counters doesn't mean give me all of them).

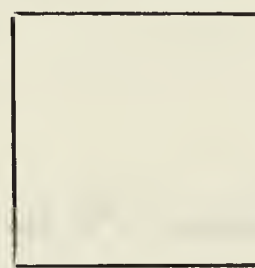
But how many is "some" if there are just two counters? All of them in this case? If there are 20, is some "a few"? If ten counters are red and ten are blue, may "some" include each color? Piaget has studied these problems as they affect the transition to classification proper. In one experiment the child is presented with counters as follows:



6 blue circles



2 blue squares



4 red squares

He is asked, Are all the blue counters circles?

Bur (6;4) No, there are blue squares. (correct)

Are all the red ones squares?

Bur (6;4) No, because there are blue squares.⁸

Are all the squares red?

Thi (6;7) Yes, with two blue squares.⁹

The structure the child is manipulating is as follows:

⁷ Ibid., p. 91.

⁸ Ibid., p. 62.

⁹ Ibid., p. 62.

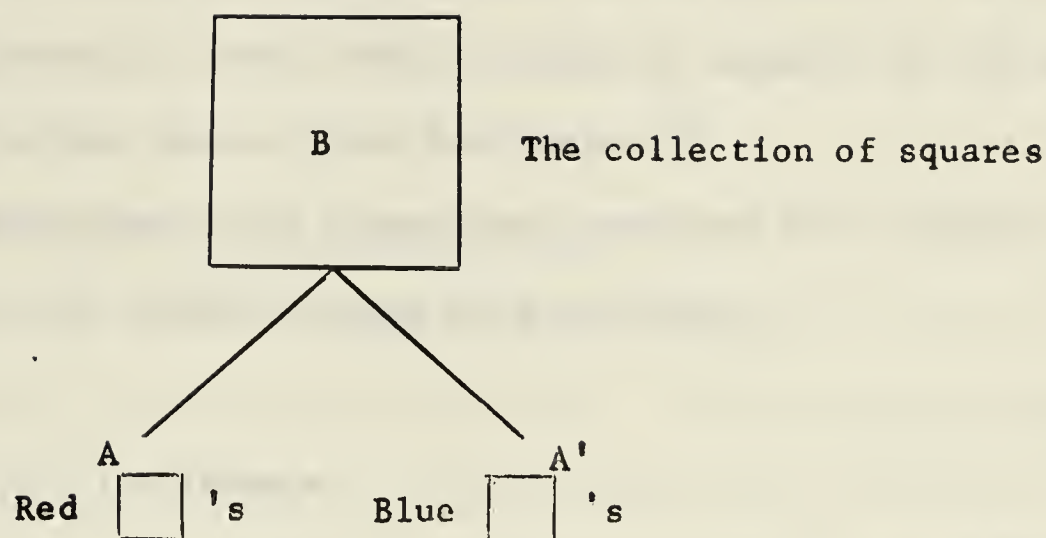


Fig. 3. -- Classification: A Dichotomy, Criterion Color

It appears that once the whole, B, (the squares) is divided into A and A', the entity "B" no longer exists; it is not conserved by the young child. He therefore compares A and A' and says in effect:

Not all the red ones are all the squares.

To appreciate that B includes A, that A is some of the B's having the property "red," he must "hold" B. He must ignore the perceptual disintegration of B into A and A' and reason in terms of the invariance of B. He must be able to hold B as a class now composed of A and A', operate on the data of the classes and their relations and come up with the implication that therefore:

$$A' = B - A$$

$$\text{and } A = B - A'$$

Piaget reports that in an experiment in which primulas and other flowers were substituted for the counters, 21 percent of the children between 6 and 8 years gave correct replies immediately to

the question, Are all the primulas some of the flowers? 49 percent persistently denied it (were unable to hold or conserve B); 30 percent accepted the correct answer after hesitation.¹⁰

The experiment with flowers was continued with children beyond 8 years. Two classifications were available.

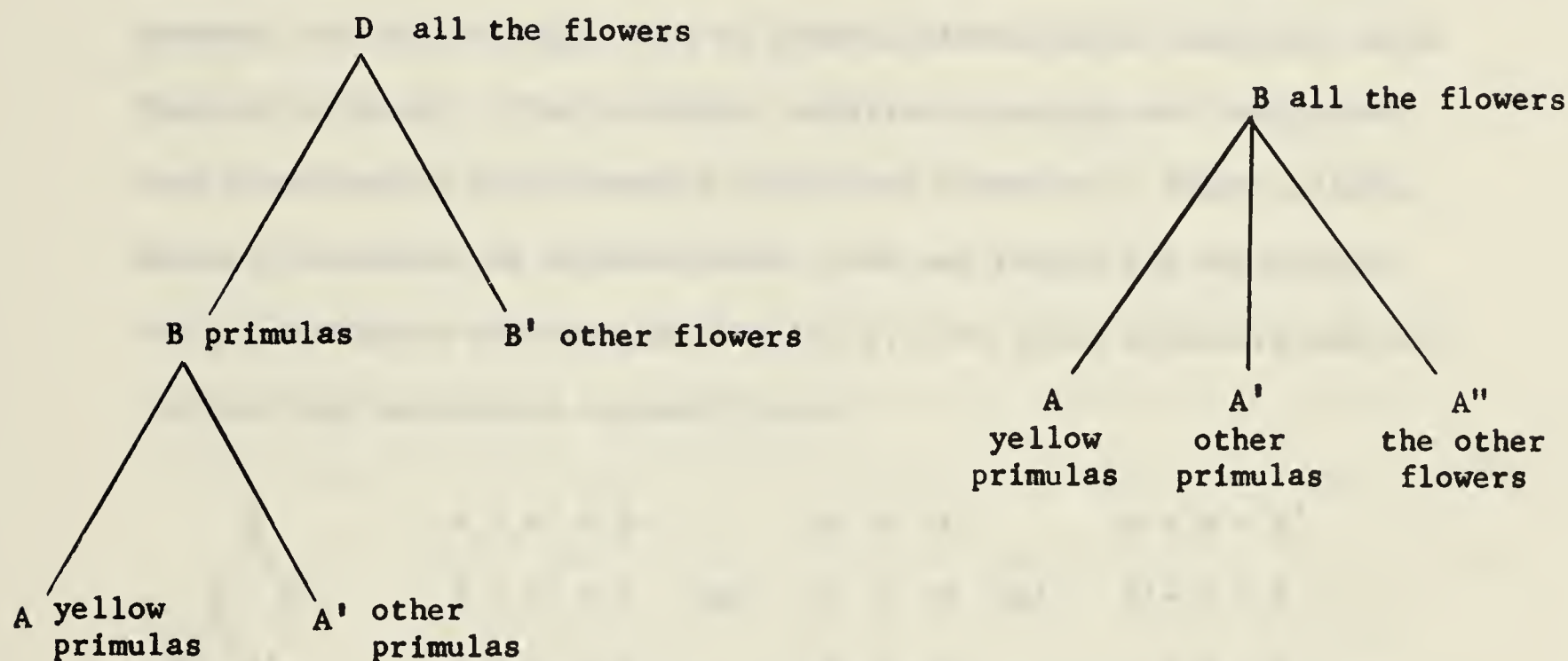


Fig. 4.-- Classification: Hierarchical Order, Class Inclusion Relations

Per (8;3) constructs the three classes A, A', A''.

He is asked, Can you make a bigger bunch with all the flowers or all the primulas?

It's the same thing, primulas are flowers, aren't they?

Are there more flowers or more primulas?

The same number. Primulas are flowers.

Count the Primulas.

Four.

¹⁰ Ibid., p. 96.

And the flowers?

Seven.

Are there the same number?

(Astonished) The flowers are more¹¹

The relationship of "some" primulas to "all" the flowers had not come to Per's attention before he was questioned. Children over 8 years, however, are increasingly able to produce hierarchical orderings (with familiar objects). They recognize additive groupings and assign correct quantitative relationships within the hierarchy. These children mentally conserve the superordinate class and relate the subordinate and superordinate classes quantitatively. The class structure and relations they manipulate correctly are:

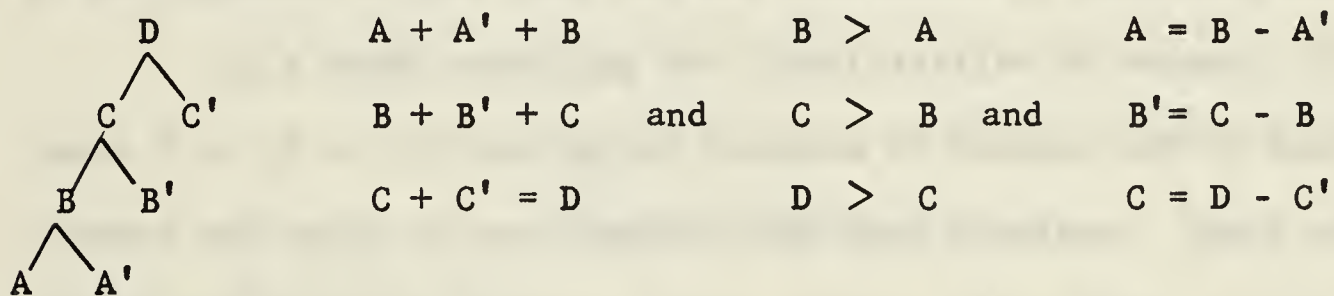


Fig. 5. -- Classification: Quantification of Classes, Hierarchical Order, Familiar Objects

Yet if children at this stage are asked about objects not readily available in their concrete experience, the quantitative relationships may escape again:

Trev (8;6) Are there more flowers or more primulas?

More flowers (correct)

What about in the woods, are there more
flowers or more primulas?

¹¹ Ibid., p. 107.

More primulas.¹²

Trev may be recalling a specific experience in order to deal with a new situation, the logic of which has escaped him. Piaget suggests it is the remoteness of the material which creates the problem. Children, however, invariably think they understand and they answer with confidence. Their errors are not mere "slips of the tongue" as they sometimes appear to be. Piaget finds a lag of this kind is also present when some children 8 to 12 years are asked to classify animals. In this situation the children appear to be ordering concepts linguistically established for them. They pick flowers and play with counters. Animals, in contrast, are somewhat beyond the range of direct action. The extension and the intensional properties of the classes in this case are not reinforced by immediate experience.¹³

In a study requiring the classification of animals, 117 children (ages 7 to 13 or 14) were given pictures of animals and of inanimate objects and asked to put together what goes together. There were birds, flying and swimming, insects, bats, snakes, fish, dogs, a rat, a horse, etc. and inanimate objects. The class structure available was as follows: (the numbers in brackets indicate the number of objects in the class or sub-class).

¹² Ibid., p. 108.

¹³ Ibid., p. 110.

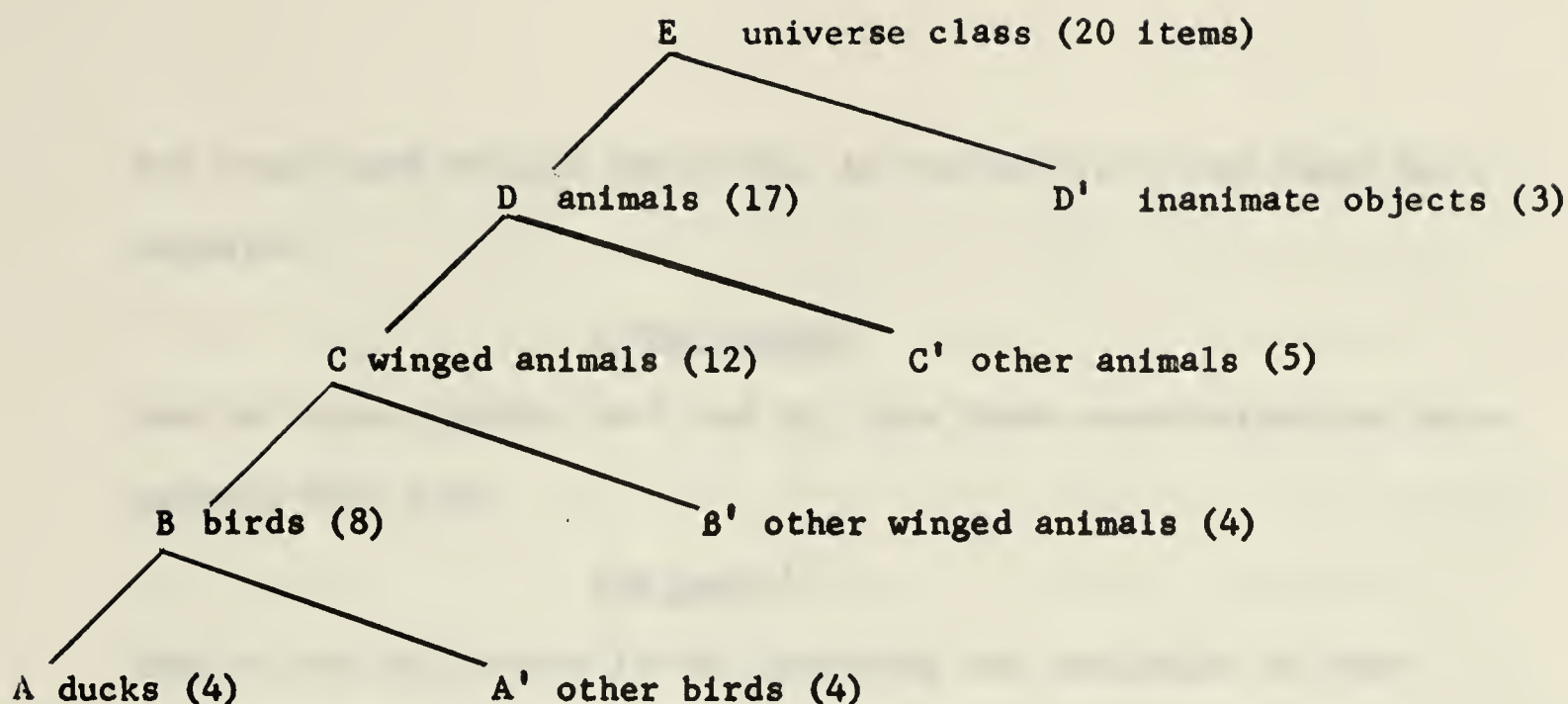


Fig. 6. -- Classification: Quantification of Classes, Hierarchical Order, Less Familiar Objects

Children, 8 to 11 years, in the protocols in this experiment present difficulties characteristic of children 4 to 6 years in the previous experiments dealing with flowers and counters.¹⁴

Stod (8;11) explores various classificatory systems.

You can put all the wild animals together
against the tame ones.

(i.e., the "not-wild")

Or you can put them so they get bigger
and bigger.

He is asked, If a hunter managed to catch all the birds would there be any animals left?

No.

And any mosquitoes?

Oh yes, if you just killed all the birds
there would be butterflies left.

¹⁴

Ibid., pp. 110-112.

Are there more animals which fly, in the world, or are there more animals?

I don't know.

Look at these (points to C and D). Are there more animals or more animals that fly?

The same.¹⁵

None of the inclusions in the hierarchy are available to Stod:

A B C D

Lou (9;11) In classifying animals Lou reverts to juxtaposed collections of equal rank showing no coherent structure.

Asked, Could one put the birds in the collection of animals?
she replies,

No.

But are they animals or not?

Oh, yes.¹⁶

The trend in the protocols indicates that if the child is successful with the hierarchical classification, he is likely to manage the quantification of inclusion as well.

Merm (12;9) constructs the classes.

Are there more animals that fly or more birds?

More birds, because there are more different types ... oh no! more animals that fly.

More animals, or more animals that fly?

More animals, because the animals include all the other kinds.¹⁷

¹⁵ Ibid., p. 113.

¹⁶ Ibid., p. 114.

¹⁷ Ibid., p. 115

Certain critical advances occur in these protocols between 7 and 8 years, between 9 and 10 and again between 11 and 12 years. Between 7 and 8 years the child gains control of the hierarchical arrangement of familiar objects. Between 9 and 10 the intensional characteristics are coordinated with their extension to "all" members (every member) of the class. The array is therefore quantified by "some" and "all" so that both the additive grouping ($A + A' = B$) and the inverse grouping ($A = B - A'$) are available. Between 11 - 12 years the child no longer requires the members of the class to be familiar or to be within a known range. He operates with linguistic categories and he is aware of the logical necessity of the operations he performs.

IMPLICATION OF THE DEVELOPMENT OF HIERARCHICAL

CLASSIFICATION FOR COMPREHENSION IN

READING

Reliable, unambiguous, shared classifications of the fundamental categories of experience (living - non-living, time, space, number, relation, probability, etc.) appear to be a necessary condition for communication - one of the necessary conditions. Such classifications are social constructs, achieved by each individual by means of, and during the process of communication.

Uznadze, whose work is discussed by a number of contributors to Recent Soviet Psychology, points to the fundamental importance of classification for individual meanings and to its social origins. Uznadze states that,

No matter how closely the complex of sounds was associated with the concept of certain objects (the word and the object it represents) it was not perceived as a meaningful word, that is, it did not merge with its own concept ... before this social event.¹⁸

Uznadze is saying that the ability to classify depends on the act of communication. He is also saying that "first order" concepts and the words associated with them, must be established and related in a system of classification within a universe of discourse before they are "understood" in the adult sense. This understanding is dependent on the social process, on communication, on confrontation.

Piaget and Uznadze would therefore agree that logical (cognitive) operations of classification are required to unite first level experiences of the manifest properties of objects (size, color, shape), second level experiences of collectivities based on similarities and differences (common and essential features) and third level operations of abstraction and relation of essential features to their extension in hierarchically ordered systems. Uznadze would say, for example, that objects and words, such as "train," "car," "bus," "plane," "wagon," "bicycle," "dogsled," "sailboat," "mule team," may be perceived and named and read. Such objects may also be associated "graphically" with visits, friends, games, work-to-be-done. They may be "collected" into big and little, fast and slow, for long distance, short distance. But in Uznadze's view their meaning is not fully understood until their

¹⁸ N. O'Connor, ed. Recent Soviet Psychology (New York: Liveright, 1961), p. 307.

essential characteristics have been abstracted and until there is available for thinking a set of relations placing them in an ordered hierarchical class structure.

An heuristic approach to achieving such a structure seems to be the adoption of a certain mental "set," a "what have we here" kind of attitude. This set is helpful in establishing the universe of discourse, the frame of reference, the context. In the above example, Man's Means of Transport might be tentatively accepted as describing "what we have here" This is followed by a "down" check on the elements present in a search for a dichotomy -- kinds of motive force might do -- or a time dichotomy: primitive and modern. Subdivisions produce further dichotomies.

A classification, once learned, is "stored" and may be retrieved and its relevance and efficiency as a higher-order category examined in new contexts.¹⁹ But it must first be constructed. The cognitive operations by which such classes are constructed are communicative in origin and in character. They are listening and thinking; reading and thinking; writing and speaking and thinking; and in art, making and thinking.

However, more than the abstracted classifications themselves are "stored." Uznadze stresses that there is conservation of the behavior and imagery existing prior to the development of cognitive operations and contributing to their emergence. He states that generalization

¹⁹ George A. Miller, Eugene Galanter, Karl H. Pribram, Plans and the Structure of Behavior (New York: Henry Holt, 1960), p. 178.

does not impoverish but enriches and deepens the image ... there is no rejection of the specific attributes ... but a synthesis in which the attributes are preserved in the generalized concept ... what occurs is the unification of specific concepts within the generic one.²⁰

Imagery, immediacy of response to sensory attributes and beauty, emotional response, are a part of comprehension in reading. These are preserved, enhanced, not rejected as cognitive maturity increases.

There are important parallels between the intellectual processes acquired in classification and the series of steps required in reading to find the "main idea" of a paragraph and to indicate the relationship of the supporting ideas to the principal idea. There is the necessary survey of the material as a whole; the search for possible dichotomies; the downward search for the subordinate parts of the organization. The child is also likely to make similar errors in this task as he was observed to make in classifying. He may begin by using an ascending technique, attempting to sort the details into little collectivities. He may stop with these original small collections and produce juxtaposition, rather than an integrated organization. He may block at shifting to new criteria when this is essential in order to include all the data, and so fail to see new possibilities in the material. With an ascending procedure and a loss or lack of flexibility, he may not reach the main theme, the topic or universe of discourse in the paragraph.

²⁰ N. O'Connor, op.cit., p. 319.

Teaching procedures designed to direct and control this process in reading have been developed by Lampard.²¹ The classifying "set" is clearly established by questions of the "what have we here" kind. The behavior being asked for is a survey of the whole. By accepting and listing all suggestions as to what we have here, flexibility in the selection of criteria is maintained during the early decisive stages. The problem now becomes, "which of these suggestions is the statement of the topic"?

The information in the paragraph is then elicited and listed bit by bit. Which bits go with which statement?

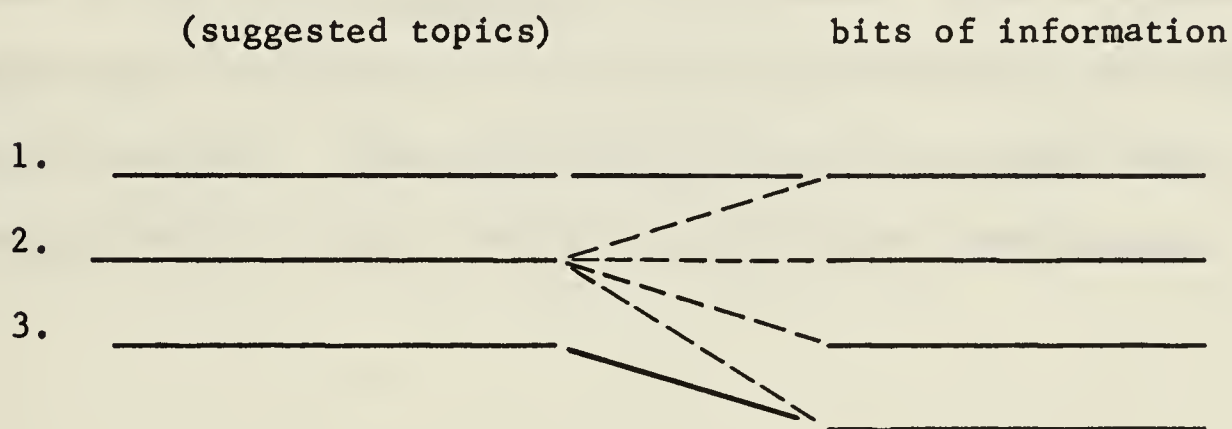


Fig. 7. -- Steps in Finding the Main Idea in a Paragraph

The "winner" takes over and is accepted as the topic. The problem now becomes, which of these bits belong together?

The "control" in this teaching situation is in inducing the selection and sequencing of an efficient classifying procedure. The over-all objective would appear to be the projection of techniques presently available to the child from his experience in ordering objects

²¹ Dorothy M. Lampard, Director, Reading and Language Centre, Faculty of Education, University of Alberta. Interview (February, 1965).

in his environment, to a new task, that of ordering information encoded in abstract signs.

In his study of children's behavior Piaget finds that the upper limits of potentiality for learning at a particular point in time are determined by the cognitive (logical) structures currently available. The extension of these structures has been shown to be related to the availability of new content, new situations to which they may be applied,²² in circumstances of confrontation with peers and adults. Piaget has also indicated that their extension is dependent on opportunities to operate at appropriate levels of abstraction, in the planned absence of concreteness. This is a condition which may be overlooked in our experience-oriented project-planning school programs. Experiences and projects have higher level properties which are made visible by appropriate classification.

²² K. Danziger, "Children's Understanding of Kinship Terms: A Study in the Development of Relational Concepts," Journal of Genetic Psychology, XCL (March, 1957), pp. 213-232.

SUMMARY

Before the child is introduced to reading-on-his-own, all the other forms of communication with the environment which he has been practising (seeing, speaking, listening, drawing, touching, manipulating, smelling, tasting) have been urged toward logical classificatory structuring by the pressures of confrontation. These structures are already approaching a classificatory ordering when he begins to read, although the relation of class inclusion will still elude the child who is unable to conserve the whole in considering its parts.

There is a risk with some children in the introduction of abstract printed signs of inducing regression in logical thinking. This regression may be limited to the area of reading, or it may include behavior in other areas of communication. This disturbance in thinking may be accompanied by symptoms of withdrawal. A traumatic reaction of this kind appears in some instances to be a response to the loss of concrete manipulation as a means of learning and to the reduction of social interaction accompanying a new learning situation. Reading disability associated with disturbances in logical development has not been investigated. It has been observed, however, that children may read with eloquence yet know almost nothing of what has been read. These comparable forms of disability may have a similar etiology - loss of the ability to operate classificatory structures when the material to be classified is represented in abstract signs.

Most children succeed in applying these essential primary logical operations to reading. In some instances, however, subsequent logical operations in which objects and ideas are to be classified in a hierarchical structure, fail to develop. In these cases, thinking which operates on material encoded in printed signs continues to be characterized by juxtaposition, by inability to use correctly the quantifying terms "all" and "some" and to perform the logical operations associated with class inclusion (for example, transitivity).

Both the methods of instruction in reading and the materials used in instruction will be related to the progress of logical thinking during the elementary school years. One aspect of this problem is that most words require to be taught as "class" words. Bicycle is not just the bicycle in the picture, or the one a child is learning to ride. It belongs to a class of objects hierarchically ordered: the set of objects of various sizes, shapes, colors, now, and historically; the set of objects having two wheels; the set of objects used for transportation; the set of objects used for transportation and operated mechanically; the set of objects operated mechanically by human power, or motor power. Not all of these relations will be "taught." What appears to be important in teaching reading is that the emergence of such relations be allowed in thinking, and that the limitations of specificity should not be forced on the child by undue "pointing" in the interests of vivid imagery. Imagery comes first. But the child's intelligence operates both on the basis of imagery and in response to the pressure of social constructs in establishing

a classificatory basis for his intelligence, that is, a basis in the logic of classes and relations.

Logical operations are extended in the structuring of longer communications as the child continues to learn to read. The extraordinary importance of the printed form of communication in comprehending hierarchical structure and relations is not always adequately presented. An oral communication, unless recorded and played back, is here and gone. It may also have followed a number of interesting but tangential routes and be subject to other interruptions. Successful note-taking in a lecture is based on prior experience in organizing a communication that stays still and may be examined visually.

Materials developed for teaching structural relations should themselves be clearly organized, but nevertheless organized in the style of good writing. This will also be an important consideration in oral-visual communication in educational-television programs. Not all of the logical operations required in comprehension should, or indeed can, be pre-performed for the reader or the viewer. Nor can a technical device be made to substitute for the functions of a developed logical intelligence. Piaget's study of the development of these functions makes it clear that each child constructs for himself these amazing characteristics of human intelligence. The surprising thing is how often children do this successfully. The difficulty in achieving efficiency in reading has demonstrated, however, that logical processes associated with abstract signs present additional difficulties. In reading the problem appears as an

inability to operate with classes, as a difficulty in ordering and organizing information and in failure to deduce the implications of communications. This problem will recur in the comprehension of materials presented in an oral-visual form in television. Logical operations belong as a right to the individual child and may not be performed by any outside agency.

CHAPTER V.

MULTIPLICATIVE CLASSIFICATION AND ITS RELATION TO COMPREHENSION IN READING

ORIGIN AND DEVELOPMENT

The child who is beginning to add classes in an hierarchical class structure (7-8 years) is also acquiring ability in double and triple multiplicative classification.

The matrix structure of multiplicative classification is more complex from a logical point of view than a hierarchical structure, but perceptually it has a certain advantage - the advantage of "good form." Its development appears to parallel that of hierarchical classification.¹

In multiplicative classification the child begins by forming an additive class, B_1 , from material classified according to one criterion, say, shape. The material, E, is classed as squares and circles, giving the additive class,

$$E = A_1 + A'_1 = B_1$$

The material, E, is again classified on the basis of a second criterion, say, color. The material may be classed as red elements and blue elements, giving the additive class,

$$E = A_2 + A'_2 = B_2$$

¹ Bärbel Inhelder and Jean Piaget, The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1964), pp. 151-171.

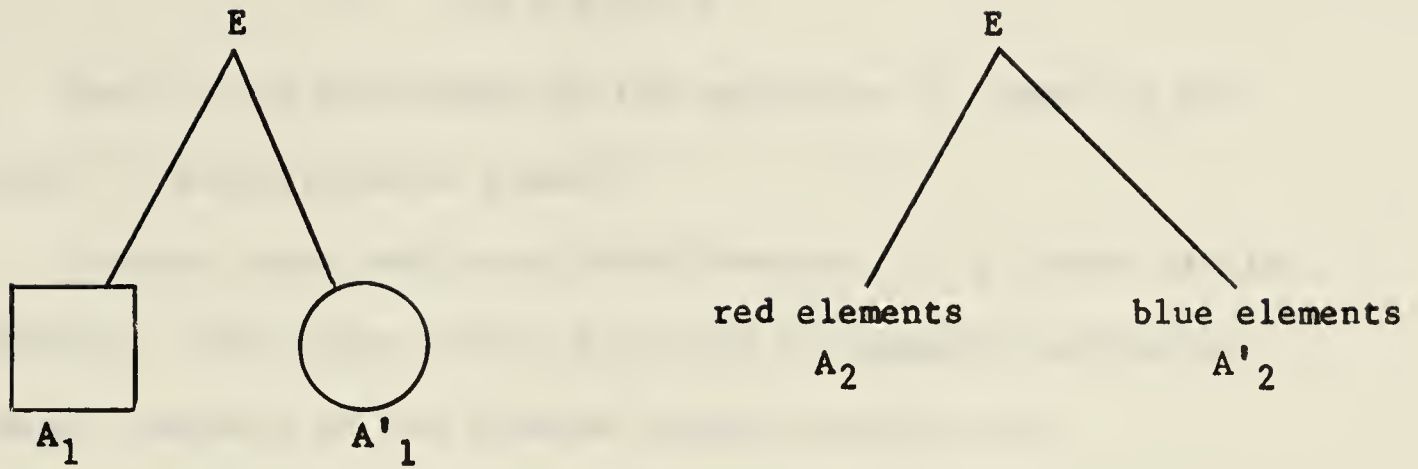


Fig. 8. -- Classification: Two Criteria Applied Successively

The next step is a new departure in classification. Each element of E is classed simultaneously in terms of the two additive classes B_1 and B_2 . The procedure yields four sub-classes in a matrix relation, in which the elements of any one class (for instance A_1) are next to each other.

	A_1	A'_1
A_2	$A_1 A_2$	$A'_1 A_2$
A'_2	$A_1 A'_2$	$A'_1 A'_2$

Fig. 9. -- Multiplicative Classification: The Matrix Form (Four Sub-classes)

In this matrix all the elements of B_1 belong to B_2 (and vice versa). All the elements of A_1 belong to either A_2 or A'_2 , but but not to both since A_2 and A'_2 (red and blue) are mutually exclusive (no element is both red and blue at the same time).

$$A_2 \times A'_2 = 0$$

Each of the subclasses in the matrix is "a class" in its own right - a multiplicative class.²

Suppose there were also black elements, A''_2 (black circles and squares). Then a new class, B_3 , would be required, giving six subclasses, composed of red squares, black circles, etc.

$$A_1 + A'_1 = B_1 \text{ as before (circles and squares)}$$

$$B_1 \times A''_2 = A_1 A''_2 + A'_1 A''_2 = B_3 \text{ (black circles, black squares)}$$

		A_1	A'_1
(red)	A_2	$A_1 A_2$	$A'_1 A_2$
(blue)	A'_2	$A_1 A'_2$	$A'_1 A'_2$
(black)	A''_2	$A_1 A''_2$	$A'_1 A''_2$

Fig. 10. -- Multiplicative Classification: The Matrix Form
(Six Sub-classes)

MULTIPLICATIVE CLASSES IN CONSTITUENT SENTENCES EMBEDDED IN A BASE SENTENCE

Each of the criteria of a multiplicative class (red, square, etc.) may be an element in a constituent sentence which may be embedded in a base sentence. The constituent sentences,

² Ibid., p. 152.

The counters are red,

The counters are square,

may be embedded (with deletion) in the base sentence,

These are counters,

producing by the rules of the grammar the derived sentence,

These are red square counters.

Such a sentence may then communicate the multiplicative class. The rules of the grammar by which constituent sentences are embedded in a matrix sentence is a part of the study of the (categorical) rules of a generative grammar. These rules "demonstrate the knowledge of the language by a speaker-hearer."³ They are not a model of the way a speaker or hearer proceeds; they simply describe his implicit knowledge of the language, that is, what he knows that enables him to understand indefinitely many sentences, even sentences which have not been spoken before.

One description of the derivation of a sentence in which the multiplicative class "red square counters" $[A_1 A_2]$ occurs, may be presented in this way, following Klima.⁴

$$\begin{array}{l} S_1 \left[\begin{array}{l} \text{These are counters.} \\ \\ \end{array} \right] \\ S_2 \left[\begin{array}{l} \text{The counters are square.} \end{array} \right] \end{array}$$

S_1 may be embedded in S_2 as a relative clause producing the derived sentence,

$$\Longrightarrow \text{These are counters [which are] square.}$$

³ Noam Chomsky, Aspects of the Theory of Syntax (Cambridge, Mass: M. I. T. Press, 1965), p. 9.

⁴ Edward S. Klima, "Relatedness Between Grammatical Systems," Language, XL, No. 1 (1964), pp. 1-20.

With deletion and pre-positioning of the adjective, the derived sentence is,

These are square counters.

$$\begin{array}{l} S_1 \left[\text{These are square counters.} \right] \\ S_2 \left[\text{The counters are red.} \right] \end{array}$$

These are square counters [which are] red.

These are red square counters.

The logical structure of the multiplicative class (and of the additive classes on which it is based) are represented in the derivational structure of the sentence. The ability to construct a sentence embedding the multiplicative class is given in a knowledge of the language. The logical operations, performed in conjunction with the language, describe the data and construct the class. It would seem that the logical operations are essential in the comprehension of the class. The speaker's implicit knowledge of the rules of the language enables him to express the relation "multiplicative class" and further by embedding to relate this class to other classes and relations within the sentence. Logical processes, however, appear to operate in the construction of these classes and their relations, and in their comprehension.

Embedding operations (and therefore the increasing complexity of the relations in a sentence) may continue almost indefinitely, with a corresponding increase in the complexity of the logical operations involved. The multiplicative class, "red square counters," may be

embedded as constituent sentences in a sentence in which other constituents are embedded.

Jane wants these counters [#S#] [#S#]

Jane wants these counters [the counters are red]

[the counters are square].

Jane wants these counters [which are] red

[which are] square.

Jane wants these red square counters.

Jane wants [#S#] these red square counters.

Jane wants [Jane plays with] these red square counters.

Jan wants to play with these red square counters.

[#S#] Jane wants to play with these red square counters.

[Jane says] Jane wants to play with these red square counters.

Jane says she wants to play with these red square counters.

By continuing to embed constituent sentences [#S#] the speaker-writer increases the number of classes and their relations in the derived sentence.

SOME COMPLEXITIES IN THE DEVELOPMENT OF MULTIPLICATIVE CLASSIFICATION

1. The Three-Attribute Multiplicative Class

The complexity of the logical operations of multiplication may be increased by requiring the multiplicative classification to be based on three attributes. This produces eight subclasses (2^n , 2^3). The

criterial attributes of the multiplicative class in one of the relevant experiments conducted by Piaget were shape (squares and circles), size (large and small) and pattern (plain and striped).⁵

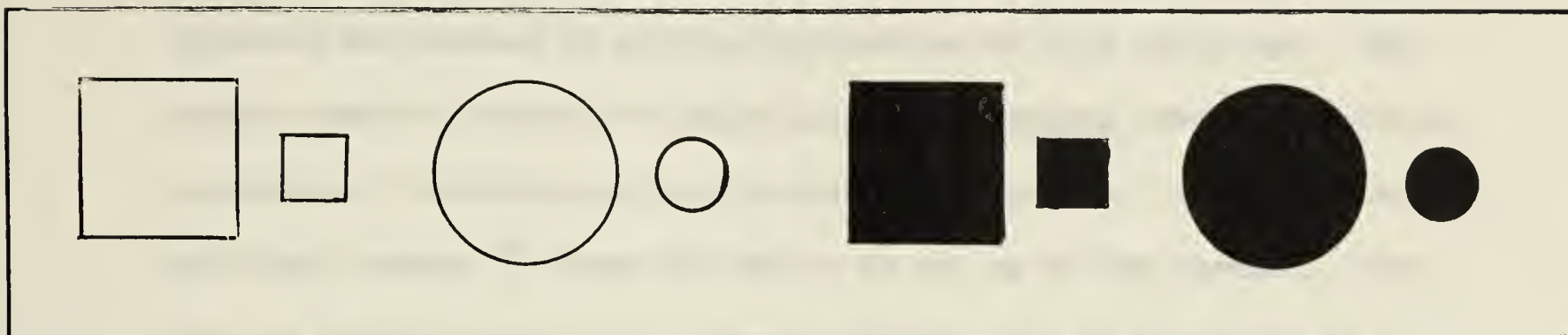


Fig. 11. -- Multiplicative Classification: Three Attributes (Size, Shape, Pattern)

In this experiment, the matrix form may be entirely constructed by the child or simply completed by him (in which case he selects, from a pile of counters, the correct unit for the eighth space in the matrix).

Fig. 12. -- Multiplicative Classification: The Three-Attribute Matrix

⁵ Bärbel Inhelder and Jean Piaget, op.cit., p. 159.

Piaget distinguishes two approaches which the child may adopt in solving a completion test involving matrices: the graphic and the operational. The first is perceptual, the second logical.

Younger children (5 to 6 years) adopt the graphic (perceptual) approach and succeed in solving the problem at this early age. The graphic method consists of neglecting the relations involved in these structures, "substituting simple spatial symmetries ... manipulated by visual images."⁶ When the matrix is set up by the examiner, leaving one square vacant, the younger children look at the whole as a configuration and correctly select the item for the vacant space on a perceptual basis.

Somewhat older children (7 - 8 years) frequently fail to make the correct selection. These older children are "thinking it out." They are trying to find the logical relations and finding the new procedure difficult. Their problem is to isolate the attributes (shape, size, pattern) and to find the pattern by which they are related.

But at this age they may be unable to "hold" the number of "chunks" of information necessary. They appear to be distracted by the attributes of the counters in the adjacent squares and so they tend to match these.

At 8 - 9 years, however, they have mastered the more advanced logical operations and are successful in using an operational technique in completing the eight-class matrix.

⁶ Ibid., p. 155.

2. Separating Out Variables and Constructing the Matrix

In studying the development of the logical multiplication of classes, the material to be classified may be presented to the child as a "pile" of objects. In this case there is no prior identification of the variables to assist the child in recognizing the matrix relationships. This is the more challenging task since the child must not only separate out the variables but apply these simultaneously to the material and then realize the matrix.⁷

In the relevant experiment Piaget presents the child with four boxes, then two boxes, then four boxes, along with the material, in order to assist him to discover the matrix. If the child fails, and instead juxtaposes the boxes, they are placed in a matrix square by the examiner.

The child is required to classify a set of materials on the basis of two criteria simultaneously. The materials are eight pictures representing,

a car,
a truck,
a motor bike,
a motor scooter,
a wagon,
a pram,
a bicycle,
a shopping basket (on 2 wheels).

One set of attributes available for classification is motorized: non-motorized; four wheels: two wheels. The crucial matter from the point of view of the child's intellectual development is the transition which

⁷ Ibid., p. 171

occurs between two distinct classifications applied in succession, and a multiplicative classification in which both are combined in the same system. Behavior appears to follow the stages observed earlier in hierarchical classification.

Stage I Graphic Collections

The children at this level repeat the behavior characteristic of "graphic collections" in which objects are arranged by use or function. The bicycle and the pram are often together in garages (Nic 5;5).⁸ There is no trace of the matrix construction in the protocols of 5 - 6 year olds, even though these children correctly complete a matrix (set up by the examiner) by reading off the perceptual symmetries. Piaget suggests that the same performance may be observed in administering the Raven Matrices Test.⁹

Stage II Successive Classification: Linear and Diagonal Ordering.

The children at this level classify on the basis of similarity but the series is successive, the sub-collections are not disjoint and the matrix is not realized. For instance, Mau (7;5) constructs two successive classifications, saying two-wheeled and four-wheeled and those that have motors and those with no motors. But he does not succeed in

⁸ Ibid., p. 171

⁹ J. C. Raven, Progressive Matrices (New York: The Psychological Corporation, 1949).

combining these classes into a system. The order is

linear

¹⁰

Sac (7;8) also manages the four multiplicative classes but not the matrix. A month later, however, he constructs these same classes, first in a row (linear), then in a diagonal (not a true matrix).

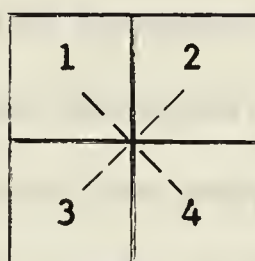


Fig. 13. -- Diagonal Positioning in a Pseudo Matrix

The diagonal ordering in figure 13 has following structure:

1. 4 wheels without a motor
4. 4 wheels with a motor
2. 2 wheels without a motor
3. 2 wheels with a motor

After several attempts, Sac is still unable to escape from the diagonal.¹¹

Stage III Realization of the Matrix Form

In achieving the transition to the matrix form, the child shows certain heuristic behavioral sequences noted earlier

¹⁰ Bärbel Inhelder and Jean Piaget, op. cit., p. 173.

¹¹ Ibid., p. 174.

in hierarchical classification. There is an uncertainty which leads to "looking back" after the second classification. There is then a "looking ahead," anticipating the second classification and "remembering" the criteria of the first classification.¹² The "looking back" and "looking ahead" together with "holding" is performed with energy and attention (with focus) and the outcome is eventually the construction of the systematic matrix relationship. Jan shows these behaviors.

Jan (7;1) Jan separates the material into two lots, motors and no-motors. Can you do it differently?

Yes. Some are wood, some are iron.

Asked again, Can you do it differently? he says,

Yes, I think I can. I have an idea.¹³

He has "looked back" and is now anticipating relationships.

When Jan says, I have an idea, he also intends to look, and hindsight and foresight begin to operate. He proceeds to cross-classify on the basis of two simultaneous criteria. Piaget considers that it is necessary that the intention to order the data be present, or the child will be unable to cross-classify. Intention, Jan's "idea," is

¹² Ibid., p. 207.

¹³ Ibid., p. 174.

accompanied by a rapid consideration of each criteria in turn, indeed a series of such rapid alternations, until the integrated system is realized in the logical form.¹⁴

When the matrix is realized as a symmetrical form, the symmetry is preserved if the partition $x \dots x$ is removed, or partition $y \dots y$ is removed.

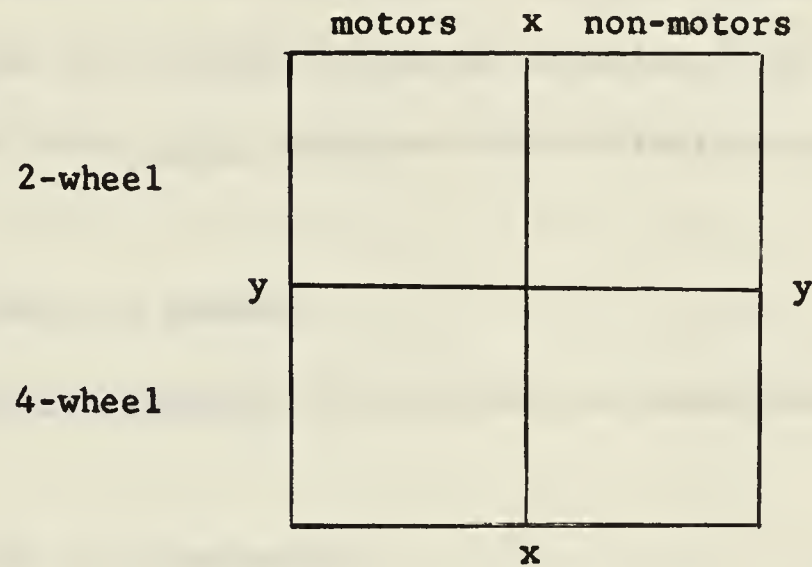


Fig. 14. -- Symmetry in the Matrix Form

The use of "or" is an important event at this point. It expresses the disjunctive relation associated with the matrix structure. The child understands that, "you can take away $x \dots x$ or you can take away $y \dots y$ -- it's still right."

This represents an early intuitive understanding of a difficult logical operator. It is here associated with the child's mastery of the cross-multiplication of classes.

¹⁴ Ibid., p. 175.

IMPLICATIONS OF MULTIPLICATIVE CLASSIFICATION

FOR COMPREHENSION IN READING

1. The Matrix Structure in the Sentence

The multiplicative class structure occurs in sentences beyond the complexity of the simple base sentence. Understanding a base sentence is, of course, no mean feat. The base sentence, for instance may express the difficult logical relation, "is a member of the class." The term, is a, expresses this relation in the sentence,

The lion is a mammal.

The relation, has the property of (attribute), is expressed by, is, in the sentence,

The lion is carnivorous.

Other relations, for instance contiguity in space as expressed by inhabits, may occur in the base sentence,

The lion inhabits the veldt.

This relation is expressed by of in the derived sentence,

The lion is a mammal of the veldt.

A logical operation (multiplicative classification) may construct a new class whose members have three attributes:

mammalian, carnivorous, of the veldt.

A grammatical operation (embedding) produces the sentence in which the multiplicative class is a constituent.

$$\begin{array}{l} S_1 \left[\text{The lion is a mammal (\#S\#)} \right] \\ S_2 \left[\text{The lion is carnivorous.} \right] \end{array}$$

The lion is a mammal [which is] carnivorous.

The lion is a carnivorous mammal.

S₁ [The lion is a carnivorous mammal (#S#)]
 S₂ [The lion is an inhabitant of the veldt.]

The lion is a carnivorous mammal (which is an
 inhabitant) of the veldt.

The lion is a carnivorous mammal of the veldt.

Linguists point to the recovery of the base and constituent sentences and the implicit understanding of the grammar of the sentence as a means for reconstructing the meaning of the sentence. Put briefly, their point is the meaning is determined in the base and constituent sentence and in the derivational history of the sentence. This is undoubtedly a helpful suggestion to the mature reader. For the young child, who is still at the stage of constructing classes and relations, it is helpful, but it appears to oversimplify his problem. It overlooks two logical operations required. The first is the construction of the multiplicative class. The second is the construction of the other sub-classes of the matrix which are "silent" or "invisible" in the communication but necessary for the comprehension in context of the multiplicative class which does appear in the sentence.

The class which appears is,

the carnivorous mammals of the veldt.

The classes to be constructed, in order to understand the visible class in context may be,

the non-carnivorous animals of the veldt,
 carnivorous animals (other than mammals) of the veldt.

But again it may not be these classes which are relevant. The alert reader picks up a clue which indicates the universe of discourse and rapidly constructs an entirely different matrix. It may consist of the "invisible" multiplicative classes,

carnivorous mammals of the veldt,
 carnivorous mammals of the rain forest,
 carnivorous mammals of the Arctic regions,
 carnivorous mammals of the tropical jungle.

Indeed the reader may realize that he will need eight classes in his matrix structure:

carnivorous (and non-carnivorous) mammals of the
 veldt,
 carnivorous (and non-carnivorous) mammals of the
 Arctic, etc.

These logical operations (selecting and constructing the relevant matrices) are simple and almost instantaneous for the competent adult reader. He tries them out for fit in rapid succession, shifting them about with no sense of effort every few lines he reads.

But this is not likely to be the case for the young child who is learning to read. It will not be surprising to find that at times children reject the effort of attention required to construct these classes and relations and simply "read the words" or read the words and supply just enough of the classification to answer a few

questions. A reader who is unskilled in using titles, headings, and clues within the sentences to direct the selection of the classifications required and reduce the immense possible total to an economical number, is more likely to need to reject the effort. The result will be that his understanding of a sentence and its context will be severely restricted.

2. The Matrix Structure as an Organization of the Whole

The multiplicative structure is not limited to the construction and comprehension of constituents of embedded sentences. The matrix form of organization may be extended over the whole of an article, contributing to the continuity of meaning between the paragraphs and to the significance of the article as a whole.

Not all articles are organized in the hierarchical form. Attempts to force material not organized in this way into the hierarchical structure does violence to its design and significance. A writer usually gives clear notice of his intentions when he selects a particular organization. The reader who can pick up clues to the structure of the whole will be able to effect notable economy in the classes, visible and invisible, which he will need to construct as he reads.

If a writer's intention is to present his material in a matrix structure, he will give the discerning reading advance notice. He may introduce his discourse by giving a prominent position to a key multiplicative class.

The vegetation on the south slopes of the higher peaks ... and follow this by abbreviated but prominently positioned suggestions to the reader as to how to proceed. He will alert him to the related classes to be constructed and at the same time warn him to "look back" and "look ahead" as he reads. For instance, the reader may find that the second and third paragraphs begin,

At intermediate levels, one finds

In the foothills, another

The writer who has concluded one division of the matrix (the x ... x, or the y ... y) at a certain point in his discourse and who now intends to move to the alternate division, will indicate what he intends to do:

Northern exposures, however, show a different pattern ...

The notice here is in the forward positioning of the phrase, northern exposures. The orientation of the reader is also a specific function of the word "however" and of the commas in this context. Since the shift to the alternate division of the matrix calls for another set of mental operations, the commas give the reader the time for this, if time is needed. In addition to the usual operations of class inclusion and the multiplication of classes, the writer here calls for the construction of a matrix which will make visible the interrelatedness of the ideas he is expressing, and represent the organization of the discourse as a whole.

The writer in his logical organization of the material directs the reader how to think in order to get the communication efficiently.

This is to be sharply distinguished from the communication itself (what to think) and from the author's purpose or intention (how he wishes the reader to feel or act about the message).

The young reader may well see in general what the writer is up to, but be tempted to settle for graphic images as suggested by individual words: "peaks," "foothills," "slopes," "levels." He will then structure the whole graphically, omitting the operational procedures. The more mature reader will use the graphic images as helps just as they were useful in actual object assembly in the experiment reported by Piaget,¹⁵ and will proceed immediately to the operational level of thinking.

As Piaget stresses, the construction of classes is an operation accomplished by thinking. Logical classificatory thinking begins with the intention to organize, and continues on the basis of of hindsight and foresight. There is an active "holding" and comparing of the classes and their attributes. There is a holding as well of any decisions made about their relatedness as reading proceeds. There is also holding and testing of emerging ideas of the organization of the whole.

It seems clear that Piaget is describing patterns of thinking, logical behavior patterns, which are invariant, that is, independent of content. Children, of course, conduct these operations on specific content, and variety of content is a great advantage in developing the logical patterns. Nevertheless, these are mental

¹⁵ Ibid., p. 155.

(logical) operations which as operations may be applied to a great variety of subject matter. As soon as more advanced operations are available, children begin to apply them to new content and it is observed that their efficiency and speed in using the operations increase with their wider application. A child may be able, for instance, to perform the logical operations required for the comprehension of a sentence having the grammatical form of a sentence such as,

Jane says she wants to play with these red square counters. But similar logical operations are required in understanding similarly constructed sentences. It is desirable that practise be provided in reading sentences with new content requiring these logical operations and having this grammatical structure.

The manager says he wants to hire these experienced bilingual applicants.

The Prime Minister announces that he intends to order heavy infantry tanks.

The expedition reports they intend to study the carnivorous mammals of the veldt.

Comprehension is not always and perhaps it is never entirely concerned with "vocabulary," "concepts," "word meanings." There are basic logical operations underlying comprehension. These operations, once acquired, apply and reapply to new content. As the materials he reads increase in complexity of both logical structure and concept, the child who is not well prepared may reject the effort at logical analysis, or simply overlook it, distracted by other matters. Many

other children appear to be unaware that they possess this powerful tool, which took so many years in the making, using it, and not using it in a haphazard fashion.

However, not all of the problem is in the child. Some of the materials he is required to read could be described as illogical in their structure, certainly as containing built-in distractors. For instance, there is at present a custom in some of the writing for children to "personalize" the sentences in order to "involve" the child as he reads,

Ted and Alice discovered that the vegetation
on the south slopes ...

This style of writing increases the complexity of an already deeply embedded sentence structure. But it does more, it disorients the reader. The superimposed element occurs in the position normally occupied by the structural clue. In itself, this added element contributes little or nothing of relevance to the theme. Yet it acts as a counter-suggestion that the material will require active structuring by the reader. It is debatable whether this style of writing is artistically or logically justified in school materials.

It appears that not only the sentence may be complicated and disturbed by including these personal elements; the organization of the discourse as a whole may be interrupted and confused by similar interjected elements.

Ted said, "Look, Alice, there is a tiny bird hopping about in that clump of" Alice ran to catch the bird while Ted examined some lichen on the rocks.

Such a pattern of discourse requires that the child be taught to eliminate irrelevant detail during the process of establishing the organization of the ideas.

SUMMARY

Piaget's research suggests that the child's growth in logical thinking depends on his abstracting, relating and organizing his experiences. In reading, the experiences are presented in symbolic form. The classes and relations (and the larger relations within the discourse) will have different logical forms: there will be additive hierarchical relations, multiplicative classes and matrix structures, and serial correspondences. Each of these forms is required in comprehending written discourse. The logical forms are reconstructed by the reader as the material is being read.

The logical reconstruction of classes and relations both within the sentence and for the discourse as a whole is accomplished in an extremely rapid and efficient manner by the mature reader. For such a reader the grammatical form, the stylistic and structural clues are completely adequate. Irrelevant elements scarcely slow the tempo.

These operations must, however, be learned in the first instance by the young reader, and then practised on a great variety of content.

Children in the process of acquiring these skills appear to use them intermittently and in a somewhat desultory fashion. It would

seem desirable as children develop classificatory skills to try to ensure that they become aware of the wide applicability, economy and power of these logical processes in thinking, as well as of their relationship to the grammatical structure of sentences, and to the organization of the ideas in the communication as a whole.

CHAPTER VI.

LOGICAL RELATIONS AND COMPREHENSION IN READING

INTRODUCTION

Piaget distinguishes two kinds of relations between events: causal and implicative. Causal (or non-logical) relations have the customary connotations -- air rusts iron; heat boils water. Implicative relations are "relations between mental states." They are "logical" relations. Flavell gives this illustration from Piaget of the meaning of implicative relations.

Just as in logic one would say that $(A = B) + (B = C)$ implies rather than causes $(A = C)$, so also one idea in consciousness is said to imply rather than cause another.¹

Morf,² one of Piaget's colleagues in Geneva, finds a related dichotomy in children's thinking about events. He reports in a study of children's responses to deductive problems, that they commonly base their answers on "causal" as opposed to "formal" reasoning. They were asked to solve problems such as the following:

¹ John H. Flavell, The Developmental Psychology of Jean Piaget (Princeton, New Jersey: D. Van Nostrand Company Inc. 1963), p. 259.

² A. Morf, "Les relations entre la logique du raisonnement concrète au raisonnement formel. Etudes d'épistémologie génétique. III. Logique, langage et théorie de l'information, ed. L. Apostel, B. Mandelbrot and A. Morf (Paris: Presses Universitaires de France, 1957). pp. 173-204.

My brother ate some meat and some soup and
 I ate some soup and some condensed milk.
 One of the three things gave both of us
 stomach pains. Can you guess which?

Children might choose meat as the source of the trouble "because meat does not keep well." They do not look for a logical or implicative solution, but rather for a "causal" solution.³

Goldstein and Scheerer make a similar distinction between two modes of behavior: the concrete and the abstract. They describe concrete thinking and acting as "directed by the immediate claims of one particular aspect of the object or of the outer-world situation."⁴

Donaldson, who discusses the studies by Morf and by Goldstein and Scheerer, comments,

One is brought to conclude, on the available evidence, that two modes of reasoning coexist over a long period - indeed, they probably exist over the greater part of life. We have seen that some children of five will on occasion deal by strict deduction with a sufficiently simple problem. On the other hand, there is evidence that adults - even rather intelligent adults - are not always rigorous when a formal problem is offered to them.⁵

Piaget's study of the origins and development of classes and relations is essentially a study of the child's acquisition of the ability to operate at the level of implicative relations, a level which requires him to "hold," to maintain loyalty to the given, and rigor in deduction.

³ Margaret Donaldson, A Study of Children's Thinking (London: Tavistock Publications, 1963), p. 203.

⁴ K. Goldstein, and J. Scheerer, Abstract and Concrete Behavior, Psychological Monograph, LIII, No. 2 (1941).

⁵ Margaret Donaldson, op. cit., p. 204.

LOGICAL RELATIONS ACQUIRED DURING THE ELEMENTARY SCHOOL YEARS

A number of the logical relations acquired during the period 5 - 6 years to 11 - 12 years have already been presented in the discussion of classificatory behavior. These relations are,

1. The relation of a member of a class to a class (a sparrow is a bird). This relation is expressed by the words, is a, and more generally in logic by the symbol $\exists$, which is read, "is a member of the class." The relation requires putting into correspondence intensional properties and their extension.
2. The relation of inclusion between a subclass and a class in a hierarchical structure (A is included in B) (birds are animals).
3. The relation between a class and its complement in a hierarchical class structure, between A and not-A, A and A' (sparrows and other birds).
4. The additive relation between subclasses and their super-ordinate class in a hierarchical class structure (sparrows and other birds are animals).

$$A + A' = B$$

$$A = B - A'$$

5. Serial relations between members of a class when these may be ordered,

$a > b > c > d$ (as is ...er than b),

together with the transitive relation,

$a > b$ and $b > c$, implies $a > c$.

6. The multiplicative class relation and the ordering of the subclasses in the matrix structure:

$A_1 \times A_2 = A_1 A_2$ (a red square counter).

$A_1 \times A_2 \times A_3 = A_1 A_2 A_3$ (a plain red square counter).

$B_1 \times B_2 = A_1 A_2 + A_1 A'_2 + A'_1 A_2 + A_1 A'_2$

(the matrix structure).

To these class relations may now be added the important relation of class intersection. The understanding of this relation appears to be basic to the child's later acquisition of concepts of conjunction and disjunction, that is, to his ability to understand the relations expressed by "and" and "or" and their stylistic variants "although," "even though," "but," "in spite of the fact that," "either ... or."

CLASS INTERSECTION:

SIMPLE MULTIPLICATION OF CLASSES

In class intersection, two classes, A_1 and A_2 , generate a new class whose intensive properties are the properties common to both of them.

In the relevant experiment, Piaget presented the child with a row of green objects (a pear, a hat, a book, a butterfly, a tulip, etc.) and a row of leaves of various colors (red, brown, yellow, etc.) placed at right angles to the first row.⁶

⁶ Bärbel Inhelder and Jean Piaget, The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1962), p. 178.

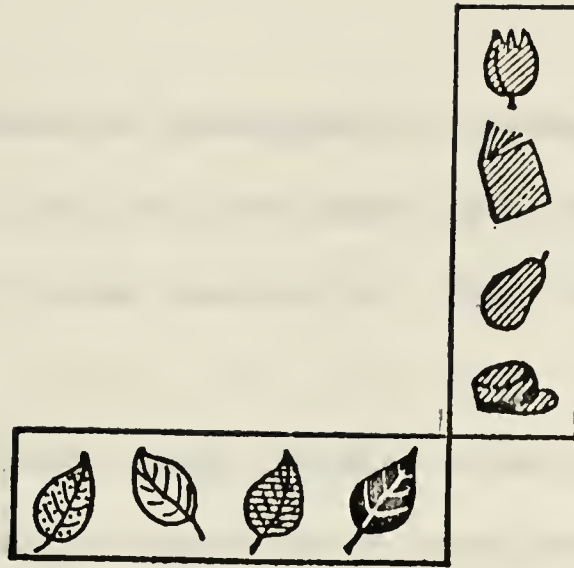


Fig. 15. -- Simple Multiplication: Test Used by Piaget in the Study of Class Intersection

The child is asked to indicate (verbally or by drawing or by selecting from pictures) an object that "fits in with everything" in each of the two rows (that is, a green leaf). If the problem is difficult, the effect of the intersection may be heightened by continuing the two rows so that they form a cross with an empty space at the center. Alternatively, additional rows may be added alongside the rows as shown.

Class intersection in this experiment was shown to be a more difficult task than the construction of the matrix. The 50 percent level of success is not reached for the simple intersection of classes until the age of 9 or 10, compared with 5 years for the 55 percent level of success in cross-multiplication in a matrix.⁷

⁷ Ibid., p. 158.

The sequence of development is, however, similar. The younger children (5-6) fill the empty space with an object identical in shape or color to one next to it. Their choice is perceptually determined.

At the second stage children select an object not in the original collection but which has a functional relationship with one or more elements in one collection. Or they may choose an object which forms part of a complex object.

Eli (8;9) makes a number of such choices as the rows are expanded to assist him.

Eli (8;9)... A tree trunk (green) because a leaf
does grow on a tree trunk.

* Somebody to read the book (one collection
only).

Would it go with these leaves?

* No, there has to be a gentleman to
look after the leaves.⁸

Ani (9;6)... selects ... a plum. Why?

* Because the leaves are almost like a plum.

He is shown a row of cats and a row of purple objects as test material.

For the intersection he suggests,

* A ball of wool because cats play with
wool and because it's purple.⁹

⁸ Ibid., p. 180.

⁹ Ibid., p. 180.

These are, on the whole, primitive reactions, as Piaget points out. The child does not understand the classificatory nature of the task. The relations he selects are part-whole or functional. He is not able to abstract the common property, to which he may then apply "all" correctly to denote its extension.

All of these are green -- and all of these are leaves.

The correct solution, in which explicit reference was made to the class using the quantifying term "all,"

all of these ... and all of these ..., occurred in the protocol of a mature 7 year old. This is, of course, a reflection of the wide range of comprehension in reading found in any classroom.

Dam (7;0) Dam is shown a row of flowers and a row of pink objects. He says,
A pink flower.

He is then shown a row of cats and a row of red objects.

A cat ... (silence)

A red cat! because these are all cats
and these are all red.¹⁰

The proportion of children 5 to 10 years who achieved correct answers (on the level of Dam) is given by Piaget.¹¹ The 50 per cent level of success on this test is reached at 9 - 10 years.

¹⁰ Ibid., p. 184.

¹¹ Ibid., p. 184

TABLE I

Percentage of Correct Answers on Intersection
Test of Children 5 to 10 Years

Age	5 - 6	7 - 8	9 - 10
Percentage	12.5%	30%	50%

Achievement on the matrix tests based on 14 items involving the multiplication of both two and three attributes is given by Piaget.¹² The 90 percent level of success is reached at 9 - 10 years.

TABLE II

Percentage Success on Matrix Tests Involving
Two and Three Attribute Items for Children
4 to 9 Years

Age	4	5	6	7	8	9
Percentage Successes	35	55	60	82	75	90

The percentage of correct answers to questions of class inclusion given in the Table III below, show a similar continuity in development.¹³ The figures represent the percentage of correct answers of 69 subjects (5 - 10 years) in tests requiring recognition of the structures,

¹² Ibid., p. 158.

¹³ Ibid., p. 109.

$$A + A' = B,$$

$$B + B' = C, \text{ etc.}$$

The 73 percent level of success is reached at 9 - 10 years.

TABLE III

Percentage of Correct Answers to Questions
on the Inclusion of Classes for 69 Children,
5 - 10 years (Number in Brackets is the Number
of Children in the Age Group)

Age	5-6 (20)	7 (19)	8 (17)	9-10 (13)
Percentage Successes	24	26	61	73

An examination of these tables indicates continuity in the development of the different logical processes; it also indicates the contemporaneous nature of the development. In particular, these results show the greater difficulty experienced in the mastery of the relation of intersection of classes (TABLE I).

The difficulty with the logical relation of intersection may be a matter of special concern for comprehension in reading in view of its developmental association with an understanding of the relations expressed by "and" and "or." In class intersection both the correct use of the quantifiers "all" and "some," and of the relation of the connector "and" is necessary.

All of these are ... and all of these are ...

The understanding of "and" is also associated in this operation with the implicative step, that therefore the class which is at the intersection of the two classes has the attributes characteristic of each of them.

It has been noted that children at the elementary school level rarely use the word "therefore" and may not understand the operation involved in the use of this word. Piaget's results (TABLE I) show, however, that some children do in fact perform this mental operation. It may be that they are unaware that they do so, or are unable to recognize the situations in which it is applicable.

A comparison of TABLES I, II, III, shows that children's success with the operation of simple intersection of classes (TABLE I) is consistently later than their success in other operations involving classes. This difficulty appears in the child's thinking in response to a sentence such as,

The children who came early and stood in line got a seat for the puppet show.

Even at 10 years (TABLE I) he may reply,

But Johnny stood in line and he didn't get a seat.

The child has overlooked the function of the logical connector "and" in establishing the intersecting class.

It is interesting to observe that the adult response to this behavior in the child is likely to be emotional rather than logical. The adult appears to be frightened by the illogicality of the child. He appears to experience the child's reply as a threat, and to react with annoyance. Yet this is a valuable opportunity, one which the child may carefully avoid presenting a second time, for assisting the child toward a new level in logical operations.

Piaget has investigated some of the factors contributing to the difficulty of the logical relations of intersection. He has examined these problems in a series of studies dealing with inclusion relations in overlapping classes. A second series of studies conducted by Inhelder and Piaget investigate the child's problems in applying these logical relations in the solution of specific problems.¹⁴

CLASS INCLUSION RELATIONS: CONJUNCTION AND ALTERNATION

1. The Experiments

In the following experiment Piaget is concerned with the study of:

- a. The quantification of the class of simple intersection.
- b. The sequences in the discovery that three subclasses may be derived from two classes alone.

The recognition of three subclasses, and the understanding of the interrelations of these is the basis of the comprehension of the logical connectors "and" and "or" of class inclusion. These operations of conjunction and alternation, together with the operations involved in understanding multiplicative classes embedded as constituents in base sentences are fundamental logical operations in reading comprehension.

¹⁴ Bärbel Inhelder and Jean Piaget, The Growth of Logical Thinking from Childhood to Adolescence (New York: Basic Books, 1958).

The materials used in the following experiment are overlapping circles and colored counters which are arranged on the areas of the overlapping circles.

The circles are black and yellow; with their overlap they define three areas: two classes and their intersection.

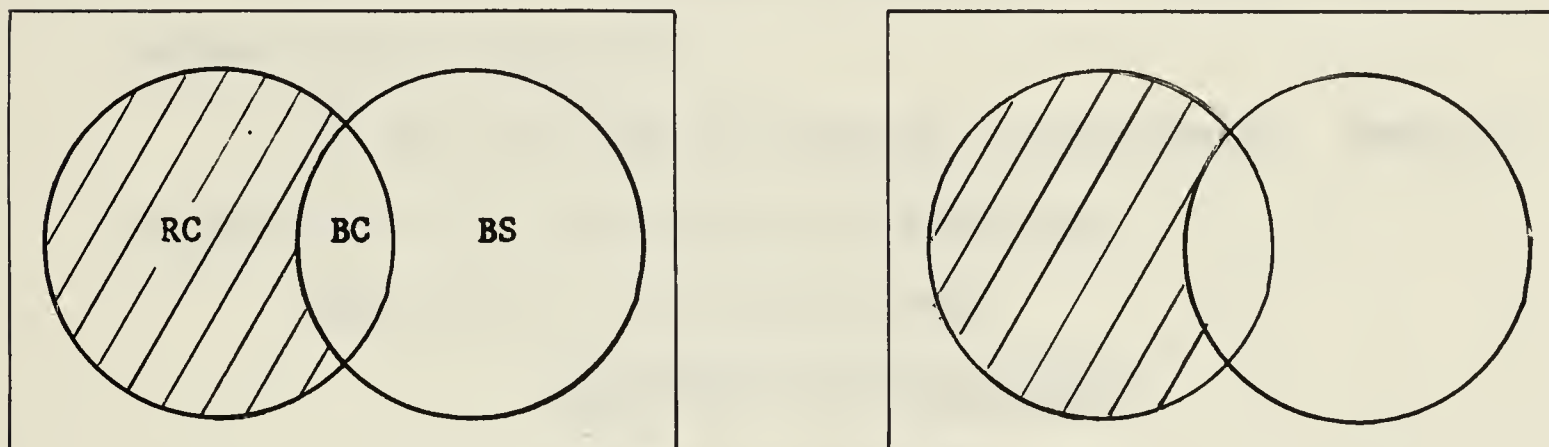


Fig. 16. -- Class Inclusion Relations: Intersecting Classes

Counters are arranged on one of the sheets of paper as follows:

red circles (RC) in the black circle,

blue squares (BS) in the yellow circle,

blue circles (BC) in the area common to both.

The symbolism is not mentioned to the child. He is asked to describe the contents of the black and yellow circles and to say why the blue circles (BC) are in the area of intersection. The set is also removed and the child is asked to reproduce it by memory on the second set of overlapping circles.¹⁵

The younger children are likely to ignore the class of intersection.

¹⁵ Bärbel Inhelder and Jean Piaget, The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1964), p. 188.

Car (7;1) What is there in the black circle?

Blue and red. What?

Circles. And in the yellow one?

Blue squares. (forgetting the BC)

Would you show me with your fingers?

He traces the whole circumference of the yellow circle but still reports only the squares.¹⁶

At the next stage the behavior is transitional. There is recognition of the intersection with prompting.

Boug (10;4) In the black circle?

Red circles and blue squares.

And in the yellow one?

Blue squares. Show me.

He traces the yellow circle with his finger[§]

Blue squares and blue circles.¹⁷

In the following protocol the understanding is immediate.

Beg (10;5) Answers the above questions correctly and is then asked, Is there anything that strikes you about these two circles?

They cross.

Could one have put red circles in the center?

¹⁶ Ibid., p. 189.

¹⁷ Ibid., p. 190.

Yes, but then there would have been two
different kinds in each circle
 (= there would not have been any inter-
 section).¹⁸

Beg therefore recognizes the class of intersection and its relation to the other two classes.

2. Implications and Extensions

When Beg reads he will be likely to recognize three sub-classes, one of them the intersection, in sentences such as,

(Both) rain and sunshine are needed for the
 crops.

"Rain and sunshine" is the area of overlap.

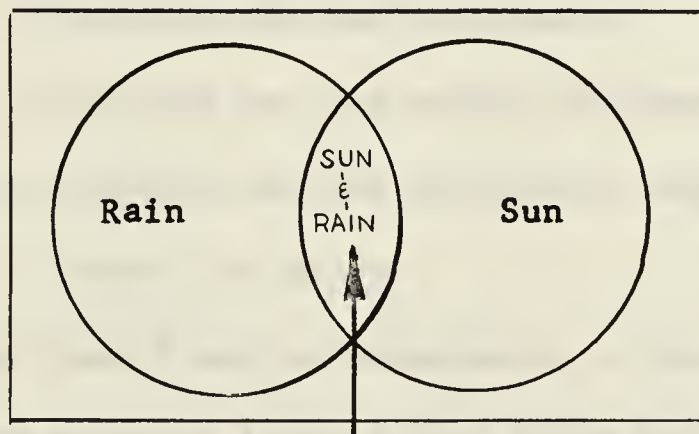


Fig. 17. -- Class Inclusion Relations: Conjunction

Children who understand the relation of classes (rain; sun) conjoined by "and" will subsequently understand statements conjoined by "and", which also generate the class of intersection. They may

¹⁸ Ibid., p. 190

also realize the negation associated with the non-overlapping and over-lapping areas. Consider the sentence,

Children were allowed to go who had obtained their parents' permission and had earned the money for the trip.

This sentence may be diagrammed,

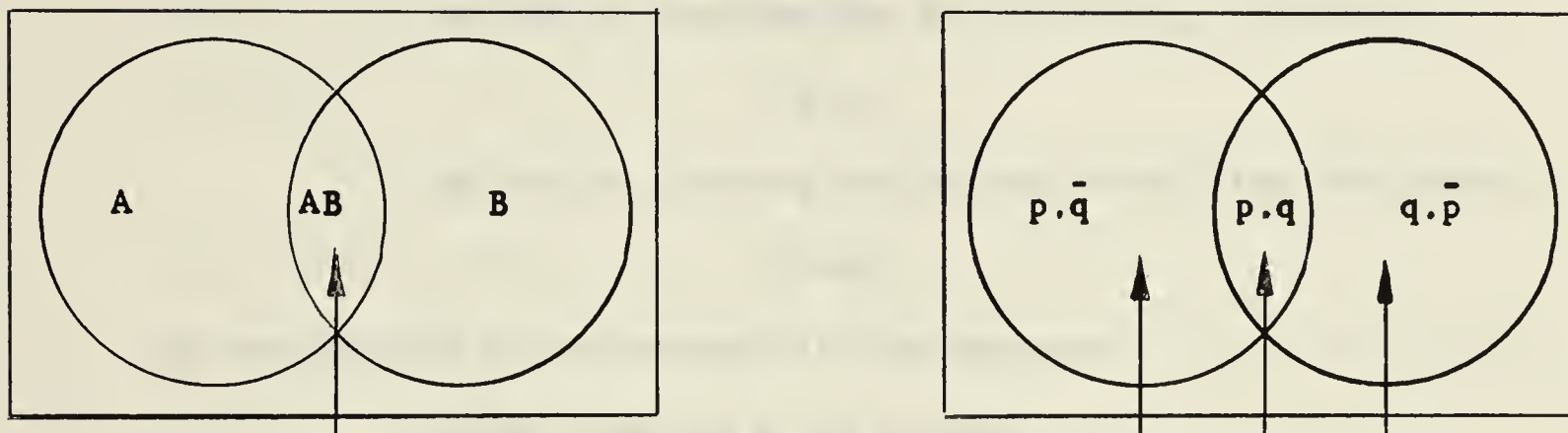


Fig. 18. -- Class Inclusion Relations: Statements Conjoined by "and"

A - children who had permission

B - children who had earned the money

AB - children who had permission and who had earned the money.

The Class A may be considered to have two attributes, one positive, one negative (notice that these are embedded sentences).

1. ... (who) have permission.
2. ... (who) have not earned the money.

If p = children who have permission, and

q = children who have earned the money, then

not -p($\bar{p}$) = children who have not permission, and

not -q($\bar{q}$) = children who have not earned the money.

The Class AB = p and q (p.q).

When overlapping classes consist of statements (propositions) they may be seen to be more difficult to understand. They involve negation and the selection of a subclass. They are represented in sentences such as these:

There had been a hot sun with no rain (for months).

$$(p.\bar{q})$$

He had no training but he was willing (to learn).

$$(\bar{q}.p)$$

He had no training and he was not willing (to learn).

$$(\bar{p}.\bar{q})$$

The conjunction is represented in the sentence,

Given time and a bit of luck

$$(p.q)$$

Stylistic variants of this "and" of conjunction present difficulties in comprehension after the connector "and" itself is understood.

These appear in the sentences,

Although the roads were icy he arrived safely.

The roads were icy but he arrived safely.

Even though he was exhausted, he pushed on.

In spite of the fact that he was exhausted, he pushed on.

He was exhausted, yet he pushed on.

These sentences may be paraphrased as,

The roads were icy and he arrived safely.

$(p.q)$

He was exhausted and he pushed on.

$(p.q)$

The difference between the original sentence and the paraphrase is rhetorical. "Although," "but," "yet," etc. are used to draw special attention to one or the other of the subclasses which are conjoined.¹⁹

These rhetorical words may also be used with negation, again drawing attention to a subclass,

Even though the visibility was not good he arrived safely.

$(\bar{p}.q)$

In spite of the fact that visibility was good, he did not drive safely.

$(p.\bar{q})$

These sentences represent an extension of the class and relational structures which are clearly assigned by Piaget to the concrete level. They introduce greater complexity in mental operations than Piaget has observed in his experimental studies in the following ways:

1. In requiring the selection of the subclass which is the negation of the classes, namely, the subclass $(\bar{p}.\bar{q})$ within the universe of discourse: the discovery that four subclasses may be derived from two classes alone.

¹⁹ Willard Van Orman Quine, Elementary Logic (Boston: Ginn and Company, 1941), p. 7.

2. In associating the negation of one subclass with an alternate subclass: $(p.\bar{q})$, $(\bar{p}.q)$.
3. In proposing that statements as well as classes may constitute the subclass; $(p.q)$ as well as $(A.B)$.
4. Perhaps also in suggesting that a fairly wide range of stylistic variant of the regular logical connector "and" may be understood at this level (though, but, yet, etc.).

Since these proposed extensions appear to be derivations of the basic class structures which Piaget has shown are available at the concrete level, it is suggested that they are also logically and practically available at the same level, with appropriate instruction.

It is remarkable that the only words in the illustrative sentences which will present difficulties in comprehension at the level at which these sentences are read will be the logical operators - the small words which are usually considered too simple to require teaching except perhaps as sight words. The difficult words for comprehension are: "but," "although," "even though," "in spite of the fact that," "yet," "and," and "not."

Perhaps one should say that it is not these words that are difficult, but the mental operations required by the words. The words themselves have no "meaning" other than the logical one. If the logical function is neglected children are forced to derive what meaning they may from experiential factors. They are forced to make use of empirical rather than implicative thinking when the latter is the form of thinking required for comprehension.

CLASS INCLUSION RELATIONS: DISJUNCTION

AND NEGATION

Overlapping classes may be related disjunctively, the alternation being expressed by the connector "or." Inhelder and Piaget have studied these relations in a series of logic-in-use experiments in The Growth of Logical Thinking from Childhood to Adolescence.²⁰

The disjunctive relations of classes occurs in sentences such as,

A bridge or a tunnel will be needed to carry the traffic.

The disjunction may be diagrammed.

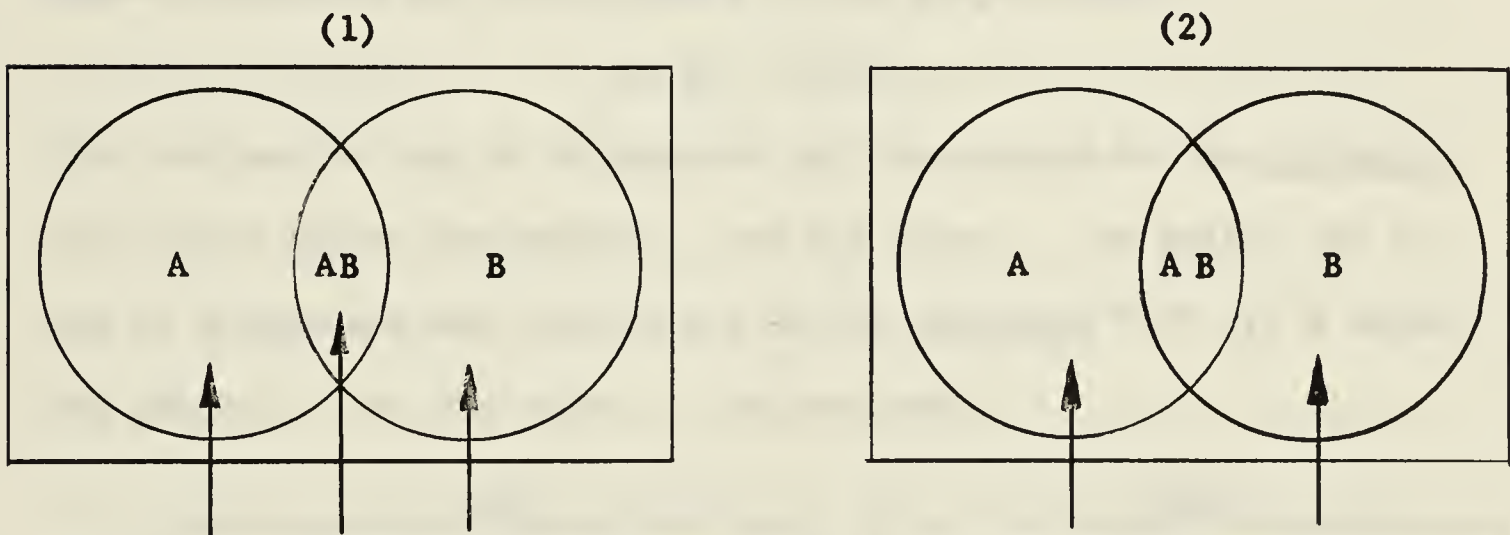


Fig. 19. -- Class Inclusion Relations: Disjunction of Classes

(1) A bridge or a tunnel or both.

$A \vee B \vee AB$

This is the inclusive "or."

(2) A bridge or a tunnel but not both.

$A \vee B - AB$

This is the exclusive "or."

²⁰ Bärbel Inhelder and Jean Piaget, The Growth of Logical Thinking from Childhood to Adolescence (New York: Basic Books, 1958).

Statements as well as classes occur in disjunctive relations, as in the sentence,

It's either the weight of the ball or the slope of the inclined plane (that makes it go into that pocket).

If "p" and "q" are taken to stand for each of the alternative statements, the alternations are:

It's the weight of the ball and not the slope.

$$(p \cdot \bar{q})$$

It's not the weight of the ball, it's the slope.

$$(\bar{p} \cdot q)$$

These statements may be expressed as the disjunction,

$$(p \cdot \bar{q}) \vee (\bar{p} \cdot q)$$

This disjunction may be diagrammed and interpreted as the inclusive "or" (It's either the weight ... or the slope ... or both). Or it may be diagrammed and interpreted as the exclusive "or" (It's either the weight ... or the slope ... but not both).

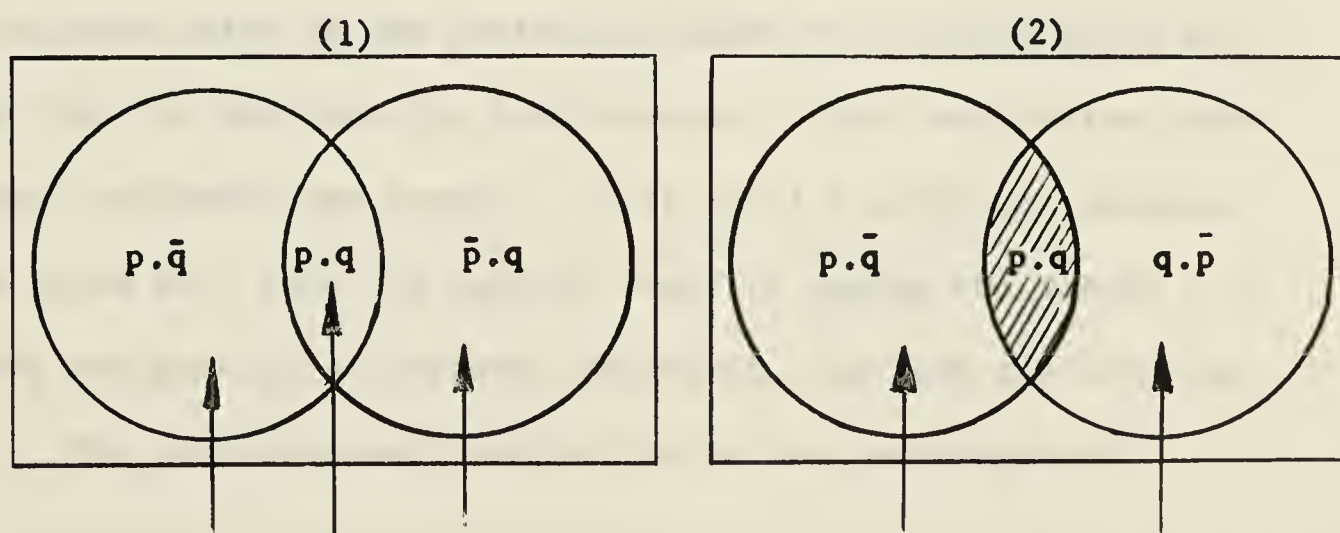


Fig. 20. -- Class Inclusion Relations: Disjunction of Statements

In (1) the arrows indicate the inclusive disjunction.

In (2) they indicate the exclusive disjunction.

To consider the negation of the whole the child requires a sentence of the form,

It's neither the weight of the ball nor the
the length of the rod nor both together
(that makes it go into that pocket).

In declaring and understanding this statement the child is indicating that the three variables he has identified and tested (weight, length and weight + length) do not explain the observed behavior of the ball (the distance it bounces). This is therefore a statement of the exclusion or negation (-) of three classes considered as variables,

$$-(p.\bar{q}), \quad -(q.\bar{p}), \quad -(p.q)$$

It involves the acceptance of the implication that therefore,

$$(\bar{p}.\bar{q})$$

is true; that is, that there exists a mechanical explanation other than the ones which he has tested and shown to be false which will account for the distance the ball bounces. This implication, when accepted, redirects the search. It is still a question, however, if the child will have the logical tools to pursue the search - to identify and test other relevant variables, and find the solution.

The exclusion and the implication may be diagrammed.

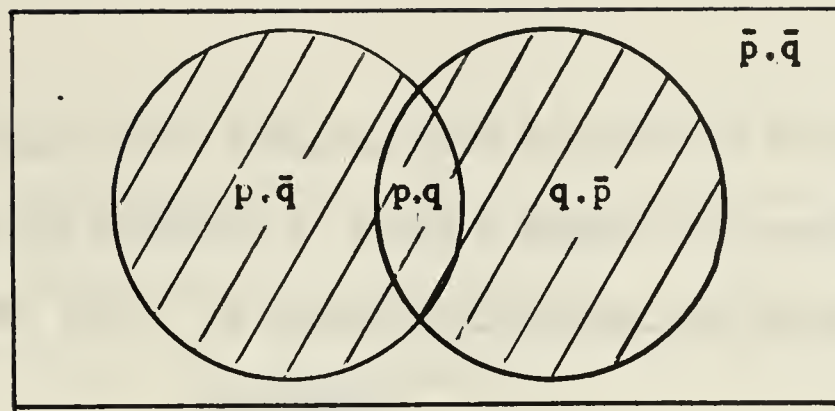


Fig. 21. -- Class Inclusion: Disjunction and Negation

These are powerful logical operations. They permit the testing of quite a number of possibilities in the total set of combinations of variables. They may also be seen to allow for the operation of implication at the concrete level.

These operations are, however, restricted at the concrete level in the number of possible combinations of variables that may be tested. At this level, the child may say, "Its something else," "There is some other explanation." But he will not yet have the logical tools for identifying and testing all the relevant variables or all possible combinations of these variables.

Piaget has examined the limits of this concrete logic-in-action by observing the child's behavior as he attempts to find answers to specific problems presented to him.

LOGIC-IN-USE AT THE CONCRETE LEVEL

Piaget has observed that disjunction is frequently combined with relations of serial ordering and with relations of equivalence for the purpose of solving problems at the concrete level. Namby, for

instance, uses serial ordering with disjunction in attempting to account for the position at which a magnetized needle will stop.

Namb (8;3) It depends on whether you turn it faster or slower.²¹

Pau makes use of observed equivalences and disjunction and arrives at an implication (the same experiment).

Pau (11;11) The round one and the star are the same weight so it could fall on either one of the two (on either this one or that one).

He then excludes weight by observing, But ... it always falls here (on star) so ... it's something else.

Pau's inference, It's something else, proves to be as far as he can go in the solution of this problem with the logic of classes and relations available to him. He continues to experiment, however, in an effort to make a break-through. Toward the end of the concrete period (11 - 12 years) children should be pushing hard against these limitations and probably experiencing considerable frustration -- or in more objective terms, cognitive conflict,²² or cognitive dissonance.²³

²¹ Ibid., p. 97.

²² Jan Smedslund, "The Acquisition of Conservation of Substance and Weight in Children. VI. Practice on Continuous versus Discontinuous Material in Conflict Situations without External Reinforcement," Scandinavian Journal of Psychology, II (1961), pp. 203-210.

²³ L. Festinger, A Theory of Cognitive Dissonance (Evanston, Illinois: Row, Peterson, 1957).

In the experiments reported in The Growth of Logical Thinking from Childhood to Adolescence, Inhelder and Piaget explore in detail certain limitations of concrete thinking in solving problems.²⁴ A critical limitation is found to be the difficulty in separating out variables for testing. One of the relevant experiments in which this problem is examined is "Falling Bodies on an Inclined Plane and the Disjunction Operations."²⁵

The apparatus in this experiment consists of a plane adjustable to various angles of incline. A ball is released at different heights on the incline. It rolls to the bottom and bounces various distances, to arrive in one of a series of pockets.

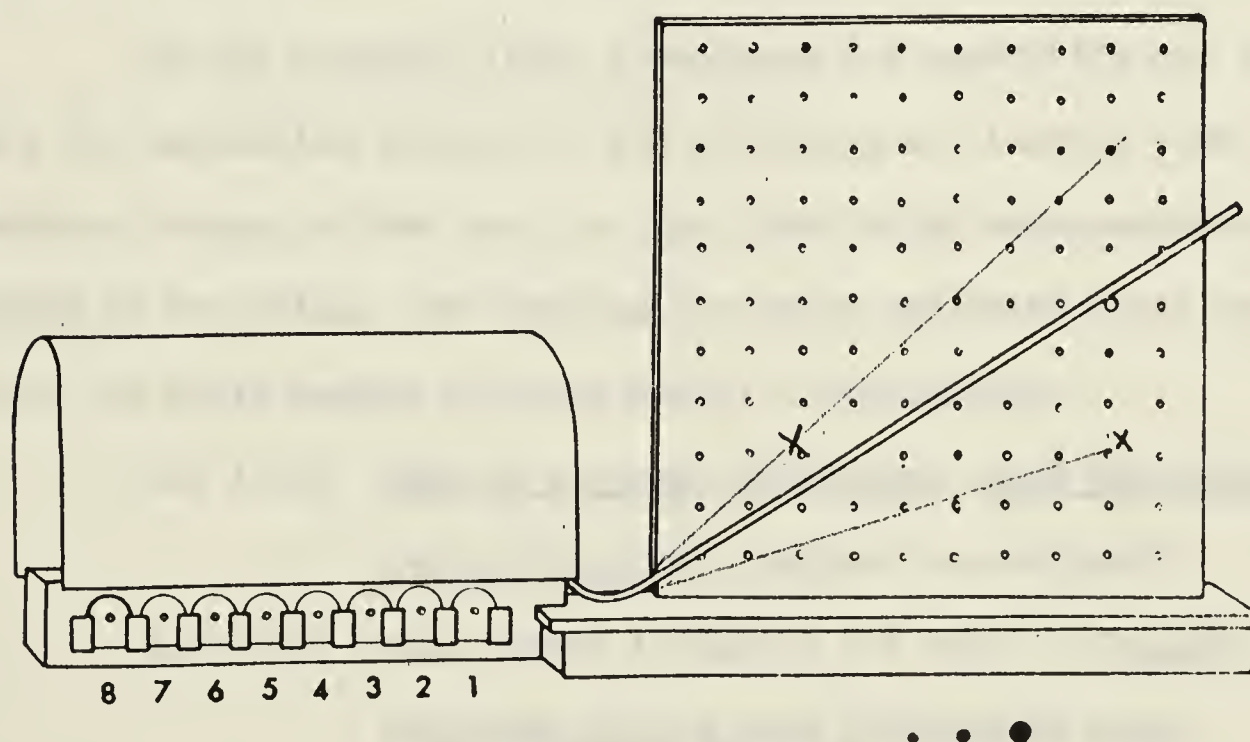


Fig. 22. -- Apparatus Used in Study, "Falling Bodies on an Inclined Plane and Operations of Disjunction" (after Piaget)

²⁴ Bärbel Inhelder and Jean Piaget, op. cit.

²⁵ Bärbel Inhelder and Jean Piaget, op. cit., pp. 80-92.

The variables which may be hypothesized as accounting for the distance the ball bounces are:

1. the weight (size) of the ball

or

2. the angle of incline

or

3. the distance from release point to the bottom of the slope

or

4. the height of the release point (slope x distance)

or another multiplicative combination of the first three variables or all of these variables or none of them.

At the concrete level procedures are apparently not available for separating out all of the variables and testing them. The variable, weight of the ball, is the first to be experimentally excluded by the child. For testing the other variables which he recognizes the child begins by using serial correspondence.

Lau (8;2) They go all over the place. Size has nothing to do with it.²⁶ (Weight is excluded).

Schi (8;) Schi thinks it may be the slope. The more you raise it the more distance it goes.
(the more ... the more).²⁷

²⁶ Ibid., p. 83.

²⁷ Ibid., p. 83.

Bli (10;2) Bli tries to vary the slope. He also uses serial correspondence. If the slope is steeper, the ball goes further.²⁸

These children are eliminating certain variables. But their procedures do not permit separating out slope and distance in order to arrive at their product: $\text{slope} \times \text{distance} = \text{height}$.

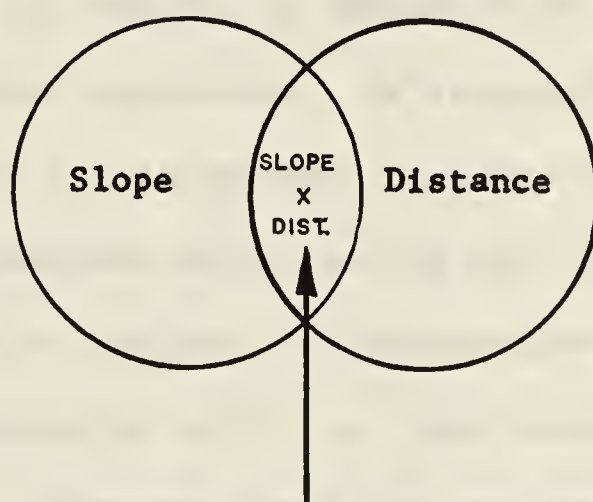


Fig. 23. -- Multiplication of Variables.

This conjunction is difficult. At equal slopes, distance and height vary concurrently.

Stro (12;6) arrives at this conjunction.

You can base it on the slope and the distance;
you multiply each hole.

How? Stro now returns to serial ordering.

A little more, a little less.²⁹

Stro separated out these alternations:

²⁸ Ibid., p. 85.

²⁹ Ibid., p. 88

It's weight (eliminated)

or

slope

or

distance

or

slope x distance = height

But he was unable to continue to operate with disjunction as he tried to verify his correct hypothesis. He returned to serial ordering.

Sal (13;3) Sal recognizes the slope-distance compensation and selects the invariant height as the sole factor. Then he states the solution so as to exclude the non-operative variables. The implication is expressed as an "if ... then" statement.

Whatever the slope you take, a large or
a small ball gets there
 (= to the same compartment)
if it takes off from the same height.³⁰

This performance is, in Piaget's account of logical growth, just beyond the resources of concrete thinking.

It is also the case that it is based on a prior competence in the logic of classes and relations developed during the concrete period. This is not the entire logic of classes and relations but it is apparently adequate to effect the transition to the formal logic of adolescence.

Sal advances from strength and accomplishes the breakthrough.

³⁰ Ibid., p. 89.

IMPLICATIONS OF THE DEVELOPMENT OF LOGICAL
RELATIONS FOR COMPREHENSION IN READING

Attempts to train young children in concepts of logical relations have been in general unsuccessful. Flavell reports a study by Morf³¹ in which Morf attempted to train for the concept of logical inclusion of classes, "the recognition that class B is both of greater extension than one of its subclasses A, and includes it ($A = B - A'$)."
Flavell comments,

He (Morf) used a variety of training procedures, all of which seemed reasonable and appropriate; but none of them made much of a dent in the subjects' pre-operational strategies. The only one which showed any promise at all consisted of training the children in the ancillary concept of logical multiplication -- the recognition that an object can belong to several different classes at once.³²

Flavell is impressed with "the apparent recalcitrance of preoperational structures to deliberately engineered, short-order reorganization."

Piaget's extensive investigations of early logical development suggest an explanation of this recalcitrance. Logical development is all of a piece. Piaget has clearly demonstrated that the many aspects of logical thinking proceed concurrently, building upon one another as

³¹ A. Morf, "Apprentissage d'une structure logique concrète (inclusion): effets et limites," Etudes d'épistémologie génétique, IX, ed. A. Morf, et al. (Paris: Presses Universitaires de France, 1959), pp. 15-83.

³² John H. Flavell, op.cit., p. 375.

they develop. To select out one of these strands arbitrarily from the total process and train for this particular skill, then proceed to another, appears to be unjustified and indeed impossible.

This limited orientation to training in logical development should also be avoided in teaching reading. Materials in reading and the questions based on them, should, on the basis of present knowledge, provide for as wide a range of early logical processes as possible. Throughout the elementary school years, provision needs to be made for a steady advance in all phases of causal and implicative thinking related to the logic of classes and relations. It appears that implicative thinking, with loyalty to the given, is the more difficult to achieve. If training in disloyalty to the given is to be avoided, children's responses to questions such as "what they would think," and "what they would do," and "what is going to happen next," must be carefully evaluated. "Creative" thinking is itself based on logical processes. There are also situations in reading in which logical thinking must be based precisely on the data as given.

It seems clear from the studies reported that at this early level the ability to state implications and make inferences is limited - perhaps not as limited as Piaget has reported - but limited at least to the familiar and the concrete. The elementary school child is not prepared intellectually to discuss solutions to world crises or comment on complicated social issues nearer home. To encourage him to do so may be to encourage illogical thought processes.

To suggest that logical development proceeds "all in a piece" on the basis of the interdependence of these processes, and of their contemporaneous appearance in behavior, is not to neglect the fact that they occur sequentially. There is a clear sequence in the degree of complexity of logical operations as they develop over time.

Nor is the responsibility of the school for training ruled out on the basis of Morf's difficulty, or on the basis of the strong impression one gains from Piaget's studies that logical development is strictly a "do-it-yourself" affair with a competent child in charge and the only direction straight ahead. Morf made some progress in training "in the ancillary concept of logical multiplication." This may, of course, have been a matter of luck: he happened to start at a point at which these children were "ready" for progress. We match in these training experiments for age, socio-economic status, I.Q., etc., but not for what may be the significant variable in the learning situation - cognitive age, or logical age. This appears to be the additional information needed in planning for the logical development of the young child.

SUMMARY

Throughout the elementary school years, children make remarkable advances in most phases of causal and implicative thinking on the basis of the development of classes and relations. Implicative thinking, with loyalty to the given, is the more difficult to achieve. Children need to be taught to make a clear distinction during a discussion between the circumstances in which it is correct to explore in a logical manner such questions as, "what they would think" and "what they would do," and other circumstances in which one applies one's thinking to the data of the situation as given, analysing the outcome as it is presented. To allow this distinction to become blurred is to encourage disloyalty to the given. Children are quick to notice if non-sequential thinking provides an easy access to commendation on the mistaken notion that it is "creative." Intelligent behavior operates on the data when this is the type of thinking required. It notes the relations and implications of the data which less intelligent behavior fails to derive.

It seems clear, too, that the ability to state implications and inferences is limited during this early period not only by the child's immaturity in logical thinking but also by a limited familiarity with the resources of the grammar of the language. Children do not yet have full control of the grammar of either deeply embedded

statements or of statements connected by logical operators, such as "and" and "or." Nor do they clearly distinguish implicative and logical connectives from empirical connectives such as "because," "when," "then." One of the reasons for this lag appears to be that many relations which are expressed by embedding (with deletion and other grammatical transformations) have not as yet appeared in the materials they have read. These are structures which do not occur in this form in oral communication, and are therefore dependent on a printed presentation.

One gains a rather strong impression from Piaget's studies that logical development in children is strictly a "do-it-yourself" affair. Yet Morf made some progress in training "in the ancillary concept of logical multiplication." Investigations such as Donaldson's, are directed toward determining what may be a significant factor in planning instruction - a measure of logical age. But it appears that as yet no consideration has been given to determining grammatical age, which is also a critical factor in intelligent functioning.

In the meantime, the best that can be done is to construct questions which require logical operations in the answering and follow with a careful analysis of the response, both its logical and grammatical status, to determine the precise nature of the operations which produced it. From this point of view, errors are as valuable as correct responses - perhaps more interesting, in the analysis, to the teacher and to the child.

CHAPTER VII

SUMMARY: CONCLUSION

EXPERIMENTAL APPROACHES TO COMPREHENSION IN READING RELATED TO PIAGET'S CONCEPTION OF LOGICAL DEVELOPMENT

1. Experimental Approaches to Concept Development

A motivation in the teaching of reading is to contribute with all due haste to the child's escape from the social isolation and sense of ignominy that accompany primitive intellectual functioning. The child realizes that escape is worth the struggle. To him any setback is a shattering experience. He needs no persuasion that to learn to read will bring the goal in sight.

Piaget is convinced that a successful transition from primitive concepts and primitive mental processes is urgent and essential. But he also believes that it is a spontaneous development. It is fostered by the culture, but the culture (represented by adults) is, so far as his research shows, limited to co-operating with the child's own efforts, and helpful as it adjusts to his timing. Other research, conducted within Piaget's theory of cognitive development, is currently of great interest to him. In this research the hypothesis is being tested that a measure of stress induced by increasing the complexity

of a problem will heighten and focus the child's energies and direct them toward achieving a firm commitment to scientific and logical solutions.

Experiments testing this hypothesis have proceeded in alternative directions. In one approach (Smedslund, 1961),¹ procedures are developed to heighten cognitive stress by making the learning situation complex and challenging in relation to the child's development. In the other (Bruner, 1964),² sequences are arranged to take the child through to an abstract level of thinking, the final step in knowing being symbolic encoding in printed signs.

New directions such as these imply significant changes in adult relations with children in the areas affected. In this case the changes have led to abandoning "go slow" work orders, notions of the order of, "reading is fun" and that what is to be learned must be simple and related to children's "interests." Instead, effort and persistence is expected of the learner and ceilings are raised on the meaningfulness and complexity of all content presented.

These changes in attitude toward intellectual development do not, however, involve relinquishing the immense gains of recent years in other areas of adult-child relationships. Adult attitudes

¹ Jan Smedslund, "The Acquisition of Conservation of Substance and Weight in Children, V. Practice in Conflict Situations without External Reinforcement," Scandinavian Journal of Psychology, II (1961), pp. 156-160.

² Jerome S. Bruner, "Some Theorems on Instruction Illustrated with Reference to Mathematics," Theories of Learning and Instruction, Sixty-third Yearbook of the National Society for the Study of Education, Part 1, ed. Ernest R. Hilgard (Chicago: University of Chicago Press, 1964), pp. 306-335.

of cheerful acceptance, alert understanding and affection for the child have created a new atmosphere in schools and classrooms. What is involved in the change is an appreciation of the facts of life of cognitive development: that loss of the familiar and accepted will threaten present stability before it provides escape from old fears and unfounded notions, but that nevertheless the old must go. It takes courage and conviction to add to the child's stress, as Smedslund has done, in order to open the way for him to an adult knowledge of the environment.

Bruner's teaching experiment is somewhat in contrast to Smedslund's. It demonstrates an alternative approach to inducing higher level abstraction in thinking. Bruner's method is to reinstate the child's earlier sequences in learning: these are concrete manipulation, representation in images (an intuitive understanding), followed by verbal encoding. On this earlier level of knowing, there is then superimposed another level - abstract encoding in printed signs, in this case the construction by the child of formulae which present in abstract symbols the sequences and results of his thinking.

In this procedure, concreteness is introduced, then deliberately eliminated in favor of abstraction and projection. For checking and for proof there is available the return to the concrete material.

An experimental approach to the teaching of reading directed toward the possibilities inherent in directions such as these for modifying the "recalcitrance of prelogical notions" and of empirically-

based thinking will require originating new methods and materials for reading, a project that could tax the ingenuity of even a Piaget. One could begin, however, with the notion that it should be unnecessary beyond an early point for children to read extensively about what they already know, such patently obvious things as that people move in next door, that girls like dolls, that frogs jump and pets get lost, that clothes are brought in out of the rain, that you buy toys in stores and go up elevators - all of the trivia of life they have known for 6 years. And not only unnecessary; it may also be allowing them to conclude that learning to read will not make the difference they hoped for in maturity and power.

Piaget has shown there is much that is fundamental that children do not know and need to know; that they are at the beginning of a logic in thinking which requires to be reinforced by the culture. He has also shown that "telling" is not the way children acquire basic concepts. One may deduce that "quoting" and "predicting" is not the way they learn to think, and "collecting" is not the way they learn to organize ideas.

Therefore methods as well as materials in teaching reading will require revolutionary changes. Children begin to learn directly through experiences and manipulation. They could therefore experiment: pour water from one beaker to another, construct roads that went straight and others that zigzagged, roll a ball down an incline and observe it bounce. They could also discuss: how rivers started and why they flow the way they do, what clouds are made of and how they

move, what's alive and what does it mean being alive. They could dramatize genuine problems in getting along together.

This is the beginning of knowing. Children also speak about what they have done and what they have observed and what they think about it. Outcomes of this stage of verbal encoding may be written and read. What is said and written and read will for some time be incorrect and primitive. It should represent the evolution of early notions toward a scientific and logical formulation. It should demonstrate the importance of checking by a return to the data. This is a function of printed symbols, to expose one's thinking to the possibility of questioning and testing. Children will learn to say: this is what I thought yesterday, now I think

Thinking and knowing, and the replacement of primitive concepts, which is advancing at a rate inconceivable in the absence of printed symbols - this is a reasonable objective for a reading program. But reading what he can already say, presented only in language patterns familiar in daily speech, and concerned with notions irrelevant to intelligent functioning - materials at this level of significance lack power to free the child from primitive concepts or contribute to his logical development. Reading less than he can say is an offence against intelligence.

There is, of course, an initial period in which the child's attention will be directed to the discovery that printed signs and spoken signs are related in certain, and in uncertain, ways. This period will probably precede and then parallel a second period marked

by the recognition of semantic correspondences between oral speech and printed speech. Considerable attention has been given to conducting the child through these more or less concurrent periods in an efficient manner. The limited success of these efforts appears to have contributed to the persistence of a number of unexpected characteristics in primary reading materials. In one series of readers, for instance, the word "help" is read and reread over a hundred times in primer material to ensure its recognition (a minimum of five recurrences is promised). Fresh contexts for these repetitions are plainly difficult to contrive. Again, in two series of basal readers, the word "friend" refers in 9 percent its occurrences over a period of three years to an animal. "Friend" appears to describe the animal in some absolute sense rather than to imply a relationship. This interpretation may persist even into the Grade 5 level. A hero is described as having "just as many friends among animals as he did among people - some of them animals he'd rescued." The pattern is repeated when the word "enemy" is introduced: an enemy is an animal that eats an animal the child is asked to identify with. (It may also be an outlaw or an Indian). There is very little recognition that the words "friend" and "enemy" refer to the reciprocal relationships which is their meaning in adult usage.

The problem may be that words such as "friend," "enemy," "neighbor" are introduced before the child is capable of constructing the concept of a reciprocal relationship. It appears that some problems in logical thinking are presented before the child can be expected to

solve them, and others are delayed beyond the point at which the child has solved them outside the reading program. Inadequate procedures for training in decoding appear to be a factor contributing to a confused situation, in which the problems of learning to decode and the problems of learning to think are not adequately differentiated.

2. Experimental Approaches to the Development of Classification

Piaget's study of the child's acquisition of logic has uncovered unexpected complexities in the relations between language and logic during the elementary school years. Piaget points to the evolution of his own thinking in this matter in his "Comments" published with Vygotsky's Thought and Language.³ Piaget states,

It took me some time to see that the roots of logical operations lie deeper than the linguistic connections and ... my early study of thinking was centered too much on its linguistic aspects.

He agrees with Vygotsky that with young children,

words take over the function of concepts ... but the forms of the thought that the child uses ... differ profoundly from the adult's

Piaget has provided the evidence for these insights in his investigation of classificatory behavior in children (5 - 12 years). His experiments have clarified a number of problems associated with instruction in reading. It can no longer be considered a reasonable objective to bring a child's oral language into correspondence with

³ Jean Piaget, "Comments." in Thought and Language, L. S. Vygotsky (Cambridge, Mass: M. I. T. Press, 1962).

its printed form. Nor is it adequate to speak in terms of building a more extensive vocabulary or even of expanding the range of grammatical structures to those characteristic of the printed language as distinct from the spoken language. These one may indeed plan to do. But there may be a more fundamental problem than these. The problem may be that of bringing the child's logical thinking into correspondence with the logical structures of the sentences he speaks, than of the logically more complex sentences that he will read.

What is at stake in this shift of emphasis is comprehension in reading, but it is also the development of the child's intelligence, an intelligence which, as Bruner puts it, requires "a classificatory structure that makes possible the use of language as a logical and analytic tool in thinking."⁴

There are clearly other roles for language than logical thinking, roles which are given considerable weight in the preparation of reading materials. Basal reading materials, it is stated in some of the guide books, are expected to meet children's need to "escape sordid surroundings," to "lose themselves in wholesome release from their problems," "to live vicariously in a pleasant attractive home," "to adjust to their own emotional problems," and certainly to be delighted and happy with "new friends." The same materials are intended to teach children to think, to organize ideas, to make inferences - and to develop word attack skills. This may

⁴ Jerome S. Bruner, "Introduction," in Thought and Language, L. S. Vygotsky (Cambridge, Mass: M. I. T. Press, 1964), p. viii.

be asking too much of simple ad hoc accounts of children's day to day adventures in suburban living. Some division of labor among the selections for reading, in view of the problems associated with logical thinking, appears to be indicated.

At the intermediate and later levels of the elementary school, many of the stories are exciting or amusing and the articles informative. It is interesting to observe the extent of the emphasis in these materials on action. Children in these stories succeed in rescuing adults from all kinds of predicaments. They do this when they act, and act fast. Adults usually fail, since they appear to be able neither to think nor to act.

The questions suggested in teaching these stories are in the main "why" questions that call for a "because" answer. Or they are questions intended to help the children project themselves into the story situation: "How would (the story character) feel"? "Why did he say this"? Other questions ask for the order of events and require "and then" answers. Others ask for prediction: "Guess what will happen next," "Were you right"?

These are suitable questions and the material is on the whole appropriate for children to read. They simply deal with other roles of language than logical thinking and other important aspects of development than the growth of logical intelligence. But the child requires a developed intelligence as well as a healthy personality to cope with an academic career.

The informational material in the readers is used directly for the purpose of teaching thinking by teaching the organization of ideas, the outlining and structuring of the content of articles and of larger units of discourse. The outline format recommended is some adaptation of the following pattern.

- Title
1.
 - A.
 - B.
 - C.
 - D.
 2.
 - A.
 - B.
 - C.
 - D.
 3.
 - A.
 - B.
 - etc.
 4.
 - etc.
 5.
 - etc.

During instruction, the teacher elicits or provides the items 1, 2, 3, ... , requesting the children to supply the details A, B, C, etc.

There are a number of disadvantages in this procedure and in this classificatory structure.

1. The first is that items in an outline of this form will be at a fairly low level of abstraction. They will tend to be concrete details, "collected" into heaps (the 1, 2, 3, heaps). The "heaps" are juxtaposed in a linear sequence.

2. Since there is no hierarchical structure, there is no way to express the inclusion relation. What is the relation between B and C in each instance? Between 1 and 2 etc.? An attempt is usually made to suggest a relation by using a "parallel construction." The items in each division will begin with the same grammatical form, for instance,

- A. to get (land)
 - B. to find (gold)
 - C. to start (new businesses)
-
- A. by (covered wagon)
 - B. by (stage coach)
 - C. by (railroad)

This device, even when it is feasible, is capable only of listing concrete instances.

Children who are reading material at this level of difficulty, and much younger children, are beyond the stage of "collections" in their logical development. Piaget has shown that they understand additive and multiplicative class inclusion relations and are able to impose these on appropriate data.

3. This method of outlining limits opportunities for children to "struggle" with the data, to adopt a "what have we here" attitude,

to look for dichotomies, to discover the effectiveness of the downward search and the functions of hindsight and foresight in classification. At what point can they intend to classify? The search is in the main for supporting details. Relational thinking in these circumstances is reduced to a minimum.

4. There is also the problem that the outline structure itself is uneconomical for purposes of recall. It does not constitute a "plan" in Miller's terms (Plans and Structure of Behavior, 1960),⁵ (The Magical Number Seven, Plus or Minus Two).⁶ In the outline structure there are more separate items than can be held in memory and compared and considered. In addition to their number and their relative concreteness, it appears that their unrelatedness and their low level of abstraction make them unsuitable for use as general principles in interpreting new materials.

5. Finally, the thinking called for in constructing an outline of this form is causal and empirical, rather than implicative. This inadequacy is not readily apparent to the experienced adult reader who glances at the outline and rapidly extracts the logical relations not represented in its form and "stores" these for recall and use in interpreting new situations. He trusts the general principles he has abstracted and stored to help him later to reconstruct the details.

⁵ G. A. Miller, Eugene Galanter, Karl H. Pribram, Plans and the Structure of Behavior (New York: Henry Holt, 1960).

⁶ G. A. Miller, "The Magical Number Seven, Plus or Minus Two," Psychological Review, LXIII (1956), pp. 81-97.

Children who are learning to read are unlikely to do this, and they quite rightly see little value in such an outline.

Children do appear to benefit, however, from constructing an outline that represents the logical relations in the material and presents these in an hierarchical form. To organize an outline in this way they begin each time with the questions, "What have we here"? "What is the universe of discourse"? As soon as they have a few suggestions in hand, and have selected the most promising ones, they look for a dichotomy and continue the downward search for sub-topics which may also be dichotomies. Their thinking requires abstracting the common element in a large number of separate items, then producing the inclusive abstract word which represents the intensional properties and defines their extension. The hierarchical format makes visible their thinking, placing the ideas in the article in the relation of class inclusion and quantifying them (all of these, e.g., "1" are some of these, e.g., "E"). They begin with a simple structure such as this,

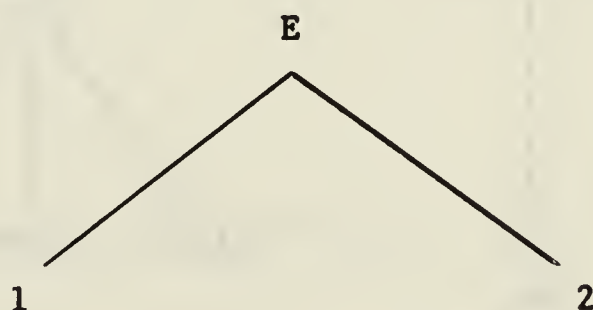


Fig. 24. -- Simple Hierarchical Structure: Outlining

Then they extend it as the material requires

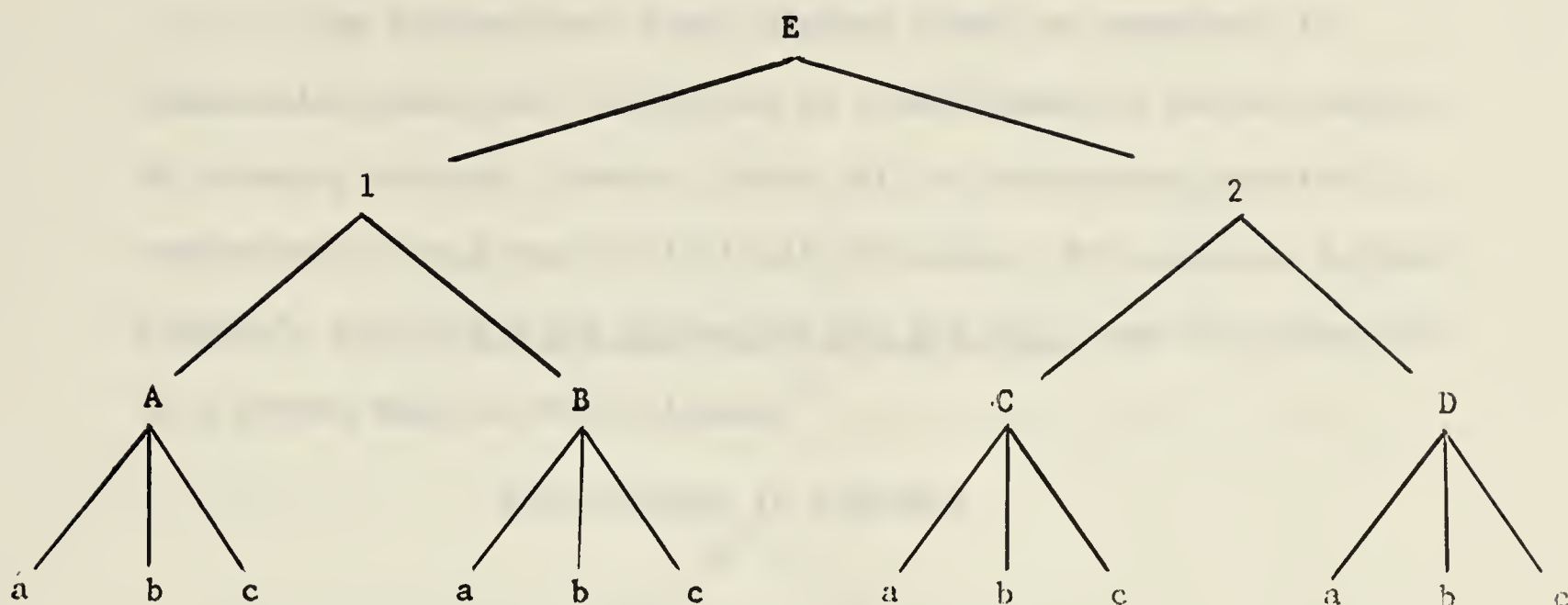


Fig. 25. -- Extended Hierarchical Structure: Outlining

In the following figure an application of this structure to content is illustrated.

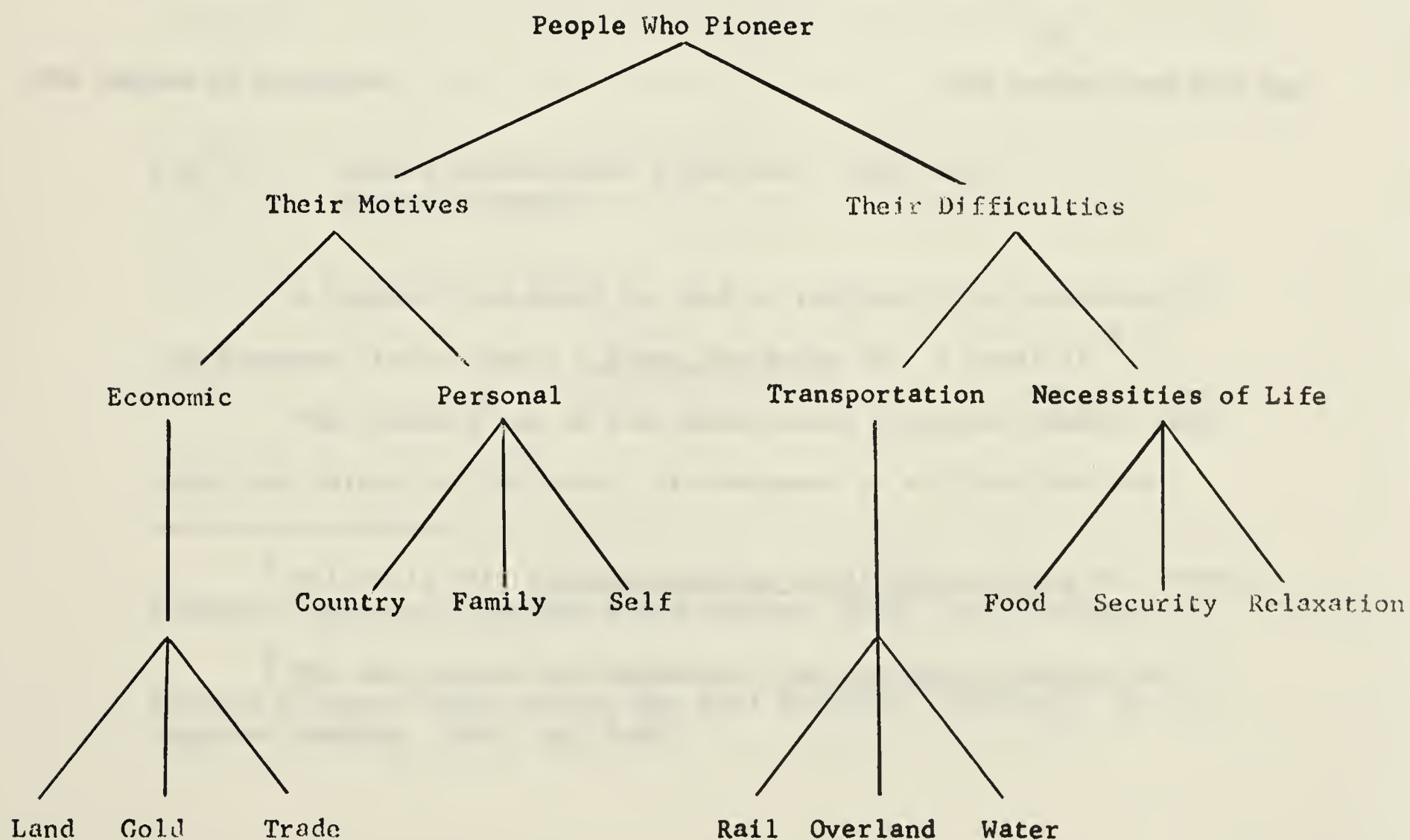


Fig. 26. -- Extended Hierarchical Structure: Outlining
Informational Content

The hierarchical form, whether simple or expanded, is essentially invariant, applicable to a wide range of subject matter. In literary writing, however, there will be interesting stylistic variations of this basic relational structure. For example, Rudyard Kipling's story, How the Rhinoceros Got His Skin, may be represented in a format such as the following:⁷

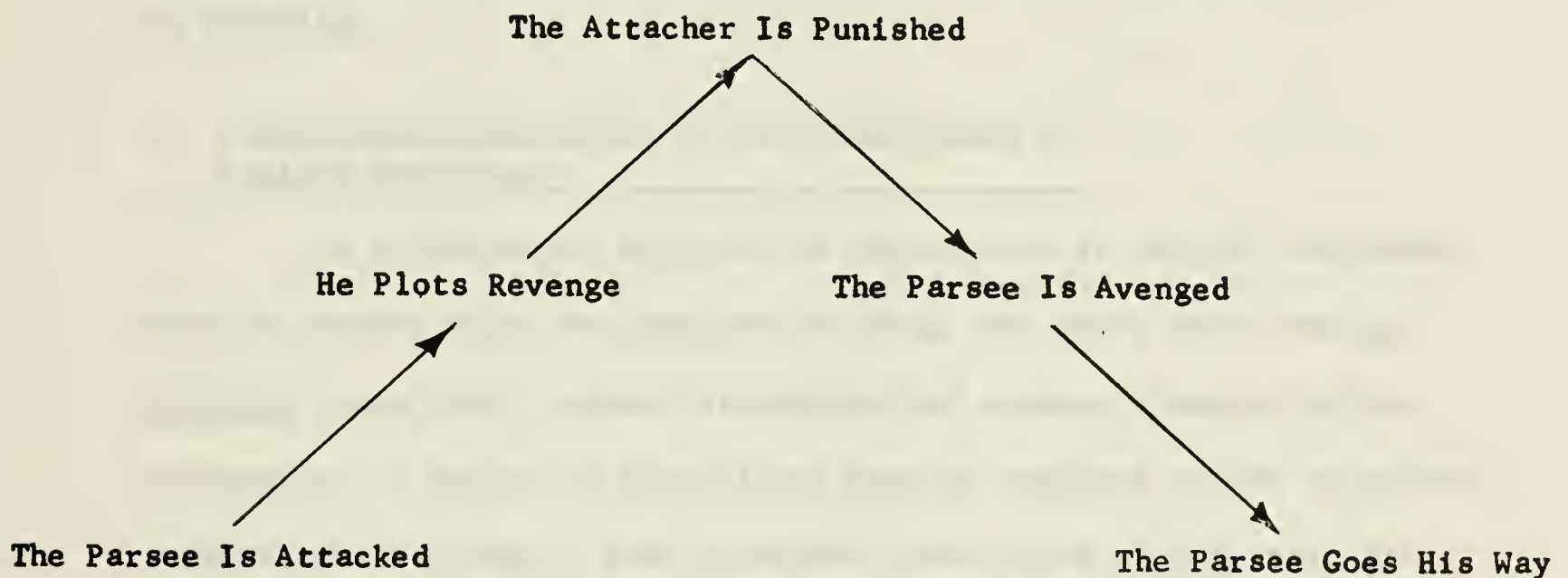


Fig. 27. -- Simple Hierarchical Structure: Outlining Literary Content

A similar form might be used to represent the structure of the pleasant little story, A Horse for Bobby (Gr. 1 Level 2).⁸

The literary use of the hierarchical structure usually indicates the balance of the story, its movement to a climax and its

⁷ All Sails Set, Canadian Reading Development Series ed. Ranton McIntosh (Toronto: The Copp Clark Company, 1948), pp. 316-319.

⁸ The New Friends and Neighbors, The New Basic Readers, ed. William S. Gray, Sterl Artley, May Hill Arbuthnot (Toronto: W. J. Gage and Company, 1956), pp. 6-10.

satisfactory return from the top. The form itself is useful to the child in ordering his thinking. It is easily recalled and may be used in his own writing. But, most importantly, it suggests to him a pattern of thinking that has a logical and implicative structure and frees him from the monotony and irrelevance of the "and then" form and the limitations proper to the causal and empirical forms of thinking.

3. Experimental Approaches to the Development of Logical Relations

An experimental approach to instruction in logical comprehension in reading might be designed to bring into sharp focus the relational terms which connect statements and connect elements within statements. A number of disciplines provide analyses of the relational terms of the language. Some important conceptions of the logic and language of relations are associated with research in mechanical translation, with studies in symbolic logic and with linguistic studies of a generative grammar.

A statement is a "statement of relations" holding between "objects" in a sentence. These relations belong to different "classes of relations," for example,

1. Bill is the brother of Tommy. (A reciprocal relation,
 $R \leftrightarrow$)
2. Mammals are vertebrates. (A class inclusion relation)
3. Bats and whales are mammals. (A relation of conjunction
 $(.)$, and a relation, "is a member of" ($R = \exists$)

4. The whale lives in the sea. (A relation of spatial contiguity).
5. The bats flew out of the caves. (A subject - phrase — predicate-phrase relation; subject - activity).

In these sentences the identification of the objects "bat," "whale," "cave," "mammal," is important. But the "meaning" of the statements is relational and expressed by the relational terms.

A statement itself may be the "object." The relation between statements will be expressed in the grammatical structure of the sentence by embedding or by conjoining by means of logical operators (and, or, and not, the full stop (.) etc.).

The full stop as a logical connective between sentences may require quite complicated mental operations by the reader. It is usually the logical equivalent of "and," but it may also invite the reader to retrieve relations from sentences extending back a paragraph, or even for the whole of the discourse. When this set of relations is recalled, it is put to concerted use at the point of the full stop.

Johnny went home. The police were waiting for him.

A pronoun such as "his" may offer the full stop an assist in a similar situation.

Johnny went home. His wife (the wife) was waiting for him.

Actually the operation required by the full stop connecting these sentences is retrieval, summary and projection of the summation into the succeeding train of thought. In all languages certain words are designated to supplement the full stop in this multiply complex role. These words appear in a forward position in the following sentences.

So Johnny went home.

Johnny, however, went home.

Instead, Johnny went home.

Clearly Johnny would have to go home.

In spite of it all, Johnny went home.

Moreover, Johnny went home.

Relational terms such as these, or the even simpler-appearing ones such as, "and," "or," "is a," "are," are not the words one looks up in a dictionary. They are easy to read and familiar in speech. Their importance in expressing logical relations may perhaps be better appreciated by omitting them. Compare the reading of the words,

and and or are

with the reading of the statement,

"and" and "or" are (relations).

The second "and" now states a missing relation.

The complexity of these relational operations became apparent in designing a machine as a model of human thinking. The function to be performed by the machine, in this situation, was mechanical translation. Some aspects of this research is described by Ceccato in a

recent paper, "Automatic Translation of Languages" in Information Storage and Retrieval (1964).⁹

Ceccato suggests that relational thinking at a simple level may be represented as setting up correlations, these correlations becoming an element in a wider net of correlations. A correlation occupies an interval of time, the same interval of time as two other items constructed one after the other. The correlator relates the first item constructed (correlatum 1) to the second (correlatum 2).

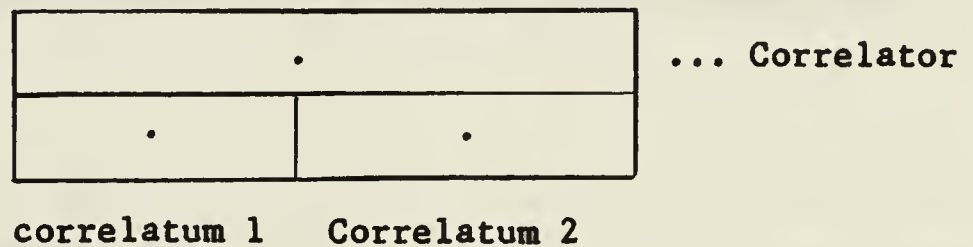
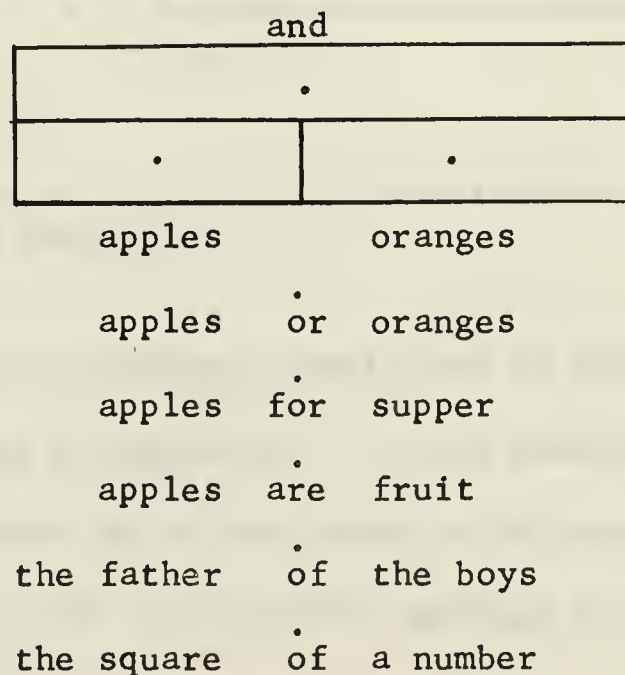


Fig. 28. -- Representation of Correlational Thinking
(After Ceccato)

This graphic form represents the relational operations in expressions such as



⁹ Silvio Ceccato, "Automatic Translation of Languages," Information Storage and Retrieval, II (June, 1964), pp. 105-158.

Certain correlators are constants: "and," "or," "for," "in," "of," "at," "if," " " , "between," "among," etc. They are mainly uninflected words, fairly limited in number, with equivalents in all languages. The full stop between sentences is usually a correlator. As Ceccato points out,

The unity of thought is not interrupted by a full-stop; if it were, instead of a discourse of several sentences, we would have several separate discourses, separate thoughts.¹⁰

When a unit is constructed in this way, it enters as an item in other correlations in an expanding net of correlations. The train of thought goes forward in a widening correlational net.

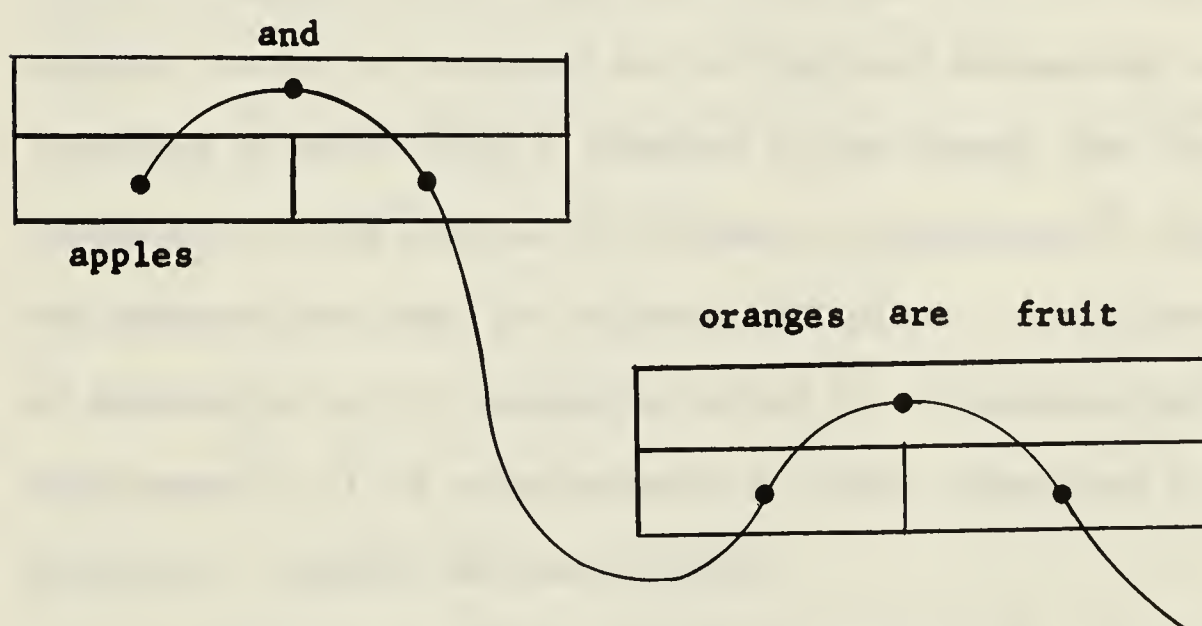


Fig. 29. -- Representation of a Simple Correlational Net (After Ceccato)

This research in machine translation is primarily aimed at "the study of man as a translator." It is intended that the machine "should reproduce as far as possible the operations of a person who translates." It is therefore perhaps only tangentially

¹⁰ Ibid., p. 110.

related to the operations of a reader who is decoding. There appear, however, to be suggestions in this approach for the study of the mental operations which lead to comprehension in reading and for the development of experimental techniques associated with these insights. It certainly indicates the importance in reading comprehension, of the "small" words.

An approach such as this which studies the relational terms within sentences could assist in the recognition of the distinction between two forms of relational thinking, the causal and the implicative, a distinction which Piaget considers essential. Piaget would have the child distinguish between causal and logical relations, and between empirical and implicative thinking. These distinctions, it appears, could be developed on the basis of attempting to categorize relations between objects somewhat in the manner that has been found necessary for the machine in automatic translation.¹¹ These categories are numerous but they are apparently finite. In any case it is not an exhaustive set of categories which is of interest for the child's development. It is superimposing on these categories a two-way classification -- logical and non-logical.

Examples in the non-logical category of relations are:

The night before Christmas,
(thing preceding -- thing following).

The kitten is in the basket,
(thing contained -- container).

¹¹ Ibid., p. 115.

related to the acquisition of a language is decoding. (Gatherer, 1977)

However, to be successful in this approach for the study of the

mental operations which lead to comprehension in reading and for the

development of appropriate techniques associated with these functions

is certainly inadequate. The importance of reading comprehension, of the

"reading" process,

the question which is this which is the logical form

which is the basis for the recognition of the structure

between the form of logical thinking, the logical and the logical

active, a distinction which is not completely essential. It is not

have the child distinguish between causal and logical relations, but

between logical and linguistic relations. These distinctions, it

appears, could be developed on the basis of accepting to recognize

relations between objects according to the manner that has been found

necessary for the analysis in automatic recognition.¹¹ These categories

are numerous but they are apparently limited. In any case it is not

an exhaustive set of categories which is of interest for the child.

development. It is superimposing on these categories a two-way classification

between logical and non-logical.

Examples in the non-logical category of relations are:

The object is a logical category.

(This preceding -- thing following)

The picture is in the basket.

(This contained -- contained)

Wheat grows on the prairies,

(thing produced -- place of production).

The boat was hauled away by a team of horses,

(thing pulled -- thing which pulls).

The fingers of his right hand ... ,

(part -- whole).

The oxygen in the air ... ,

(component -- compound).

The farm animals in the exhibit ... ,

(element -- collection).

Logical categories may be distinguished from these (and numerous other) non-logical relations. Logical categories are based in part on two important class relations:

(a) The membership of an individual in a class,

(the $\exists$ -relation).

Johnny is a clever boy.

Tornadoes are violent destructive windstorms.

(b) The relation of two classes, one of which is

included in the other (the class inclusion relation).

The reptile is a vertebrate.

Logical thinking is undoubtedly dependent on the child's increasing control of the concept of the category "logical relation." It is also dependent on a knowledge of the properties of relations. Piaget has studied the sequences by which an understanding of some of these properties is acquired, in particular the property reciprocity (brother of) and the complex properties of the relational concept

What gives the picture,

(this is pronounced -- place of pronunciation)

The book was named after by a line of books,

(being called -- being called).

The figure of the figure is...

(have -- whole).

The system is the life...

(component -- component)

The days and nights in the world...

(element -- collection)

Logical relations may be distinguished from those that

numerous other non-logical relations. Logical relations are

based in part on two important class relations:

(a) The membership of an individual in a class.

(the $\subseteq$ -relation)

Johnny is a clever boy.

Teachers are violent destructive adolescents.

(b) The relation of two classes, one of which is

included in the other (the class inclusion relation).

The relation is a hypothesis.

Logical thinking is undoubtedly dependent on the child's

increasing control of the concept of the category "logical relation".

It is also dependent on a knowledge of the properties of relations.

Bigot has studied the sequence of which an understanding of some

of these properties is required. In particular the properties of

city (whether of) and the properties of the relational concept

of nationality: "Can you be two things at once"? (e.g., an Edmontonian and a Canadian). Studies of the concept of reciprocal relations were reported by Piaget in Judgment and Reasoning in the Child, (1928).¹²

A replication of Piaget's study of children's concepts of nationality was conducted by Jahoda (1963) on a population of 144 Glasgow children, aged 6 - 11. His results differed in a number of important respects from Piaget's. But the importance of the relational notions in thinking and the difficulty of these notions for young children were confirmed.¹³

One of the properties of relations which Piaget does not seem to have studied is the converse of a relation, and the sequences in its acquisition. This relation is represented in,

employer of -- employee of
parent of -- child of
friend of -- befriended by¹⁴

These relations, and their converses are clearly important for comprehension in reading.

In a study by Halpern it appears that the ability to recognize logical relations and their properties as distinct from empirical and causal relations underlies the transition from empirical to implicative thinking.¹⁵ Experimental approaches in teaching directed towards

¹² Jean Piaget, Judgment and Reasoning in the Child (Routledge and Kegan Paul, 1962).

¹³ Gustav Jahoda, "Children's Concepts of Nationality: A Critical Study of Piaget's Stages," Child Development, XXXV (December, 1964), pp. 1081-1092.

¹⁴ C. I. Lewis, A Survey of Symbolic Logic (New York: Dover Publications, Inc., 1960), p. 274.

¹⁵ Esther Halpern, "The Effects of Incompatibility between Perception and Logic in Piaget's Stage of Concrete Operations," Child Development, XXXVI, No. 2 (June, 1965), pp. 491-495.

of nationality: "Can you be two things at once?" (e.g., an American and a Canadian). Studies of the concept of national identity were reported by Torgler in Indigenous and Immigrant in the United States, 1957, p. 12. A revision of Torgler's book of identity's concept of nationality was conducted by Torgler (1957) for a publication of the Oregon Ethnic Study. The results differed in a number of important respects from Torgler's. The importance of the national identity in such studies and the ethnicity of these nations for young children were discussed.

One of the problems of relations which Torgler does not seem to have studied is the concept of a relation, and the boundaries of it. This relation is represented in:

Employer of - - employee of
 parent of - - child of
 friend of - - friend of

These relations, and their reverses are clearly important for comparison in reading.

In a study of relations in respect to the study of cognitive logical relations and their properties we discuss from empirical and logical relations models the transition from empirical to logical relations.¹² Experimental approaches to teaching logical relations

¹² Jean Torgler, Indigenous and Immigrant in the United States, 1957, and Torgler, 1957.

¹³ Torgler, 1957, "Children's Concepts of Nationality: A Study of Torgler's Study," Journal of Educational Psychology, 1957, pp. 1081-1091.

¹⁴ D. I. Lewis, A Study of Logical Relations, 1957, pp. 1081-1091.

is further defined, "The Effects of Interrelationships between Logical and Logical in Torgler's Study of Logical Relations," Journal of Educational Psychology, 1957, pp. 1081-1091.

establishing this distinction and designed to clarify further for the child the various properties of relations should make a valuable contribution to comprehension in reading and to over-all logical development.

A traditional approach to recognizing and specifying relations in a sentence has been through classical grammar. From the point of view of this grammar (whatever the category of relations caught in the correlational net) one relation, a dichotomy, dominates the sentence. This is of course, the Subject-Phrase -- Predicate-Phrase relation (or Noun Phrase -- Predicate-Phrase structure).

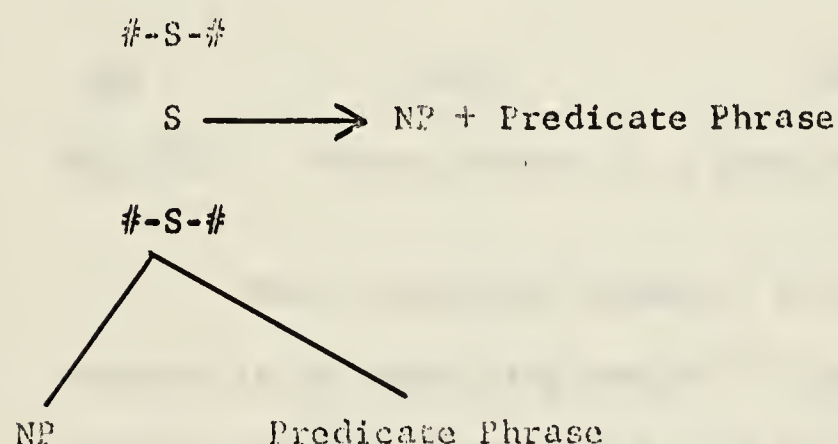


Fig. 30. -- Subject -- Predicate Dichotomy in a Sentence

This basic relational structure is readily understood by children when it is developed early in reading instruction in simple sentences. They find little difficulty later when it is systematically expanded, as in Figure 31.

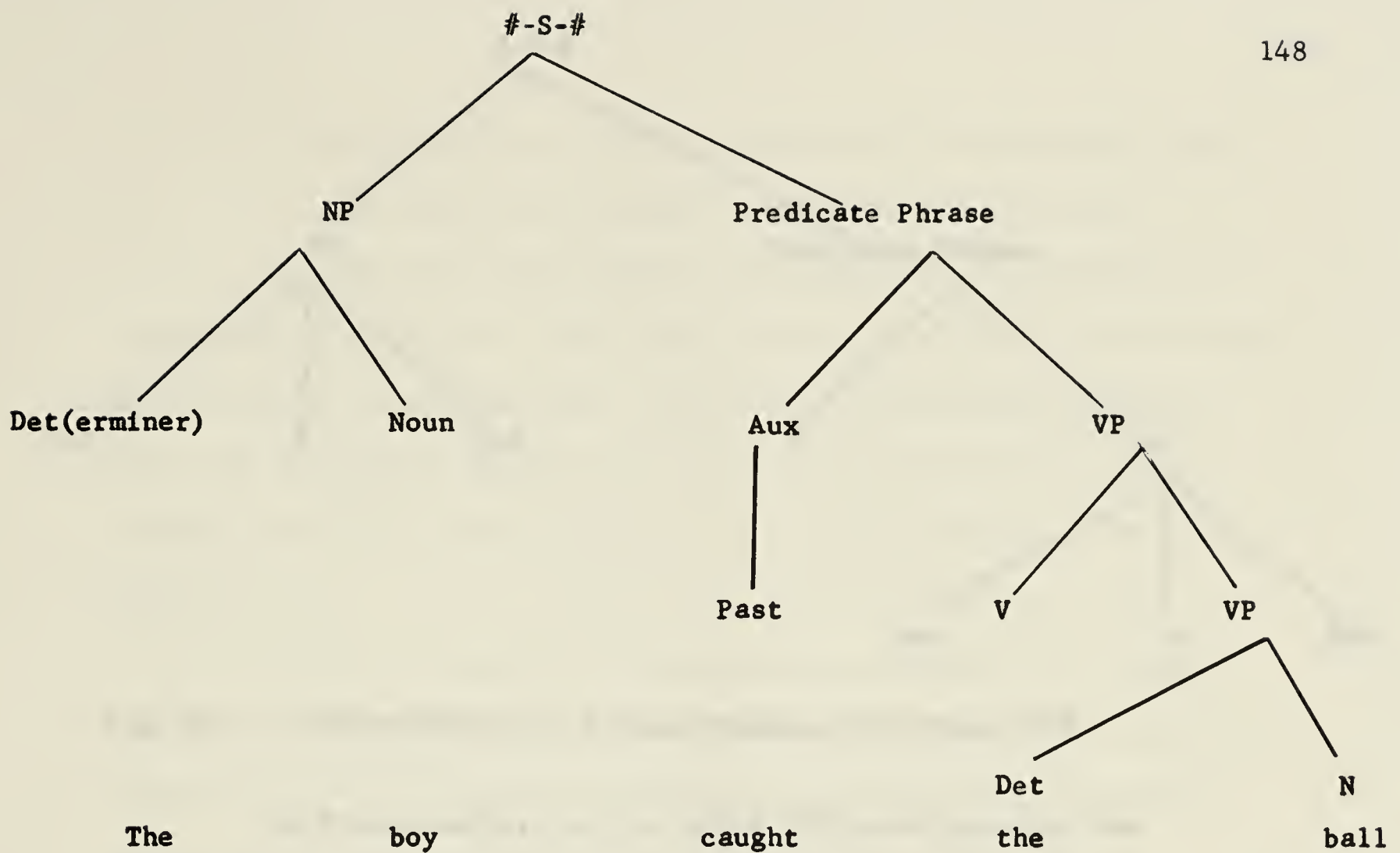


Fig. 31. -- Phrase-Marker of a Base Sentence

Most sentences, however, will have a sequence of Phrase-markers as an underlying basis.¹⁶ The Phrase-markers will be generated at the nodes, #S#, of a base Phrase-marker. These Phrase-markers generate the sentences which, by the rules of the grammar, are embedded in the base sentence. Figure 32 shows nodes #S# at which Phrase-markers may be developed.

¹⁶ Noam Chomsky, Aspects of the Theory Syntax (Cambridge, Mass.: M. I. T. Press, 1965), p. 7.

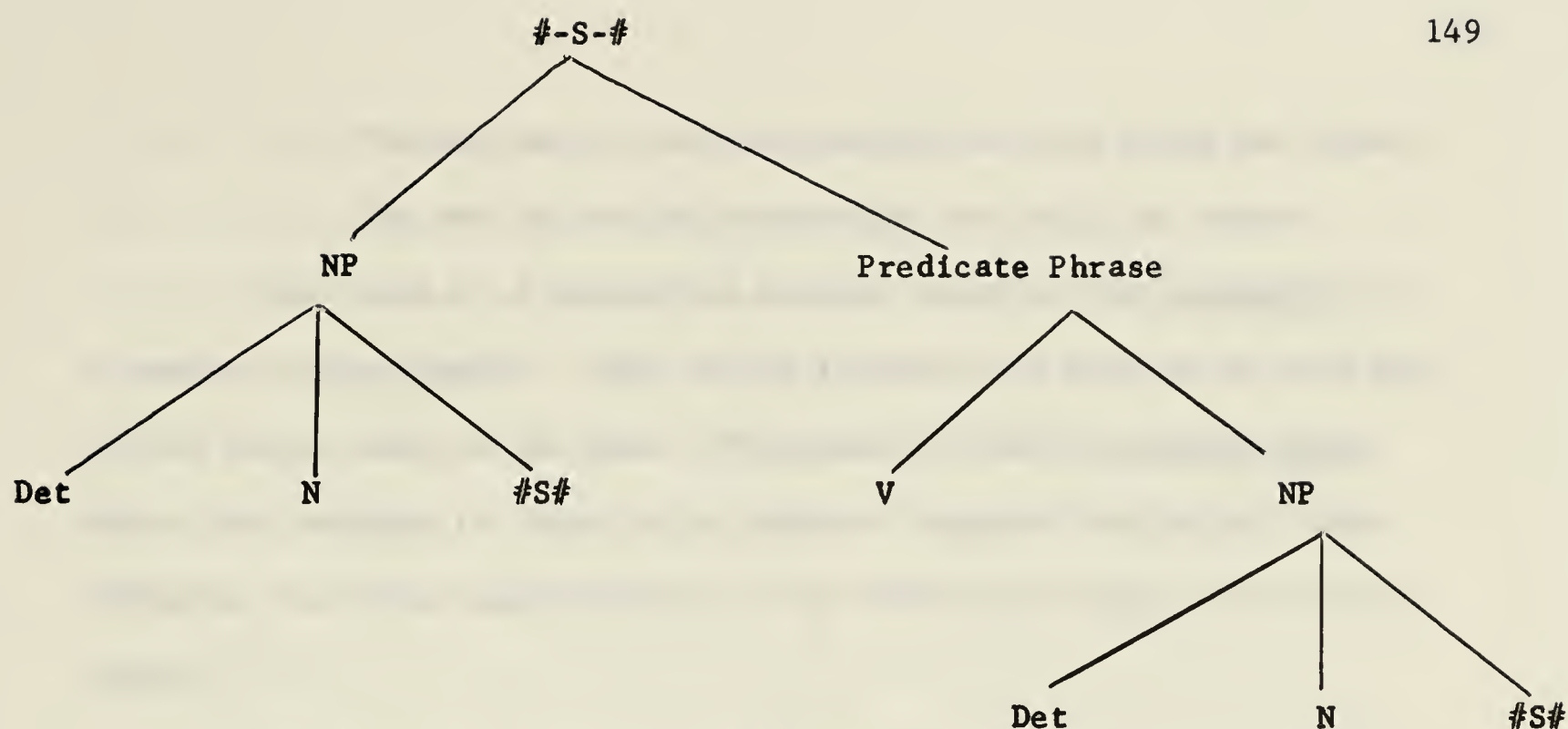


Fig. 32. -- Phrase-Marker of a Base Sentence with Nodes #S#

The Phrase-markers at the nodes #S# could generate the sentences,

The boy is new on the team,

You threw a ball.

A sequence of base Phrase-markers is then the basis of the sentence,

The new boy on the team caught the ball you threw.

This sentence may be derived by a series of transformations (embedding, deletion of common elements, prepositioning of an adjective, etc.).

The boy [the boy is new on the team] caught the ball [you threw a ball].

The boy [new on the team] caught the ball [you threw a ball].

The new boy on the team caught the ball [you threw a ball].

The new boy on the team caught the ball which you threw.

The new boy on the team caught the ball you threw.

The rules of a generative grammar describe the competence of a speaker-writer-reader. They do not instruct him what to do, and they do not report what he has done. They simply indicate what he knows about the language in order to be able to "express indefinitely many thoughts, and react appropriately in an indefinite range of new situations."¹⁷

The rules of a generative grammar are therefore not a model for the speaker-reader. They do not tell him what to say, or how to proceed to say it. They describe what it is he knows which enables him to speak and be understood, and to read and understand.

There appears to be something of a meeting of minds with Piaget in this insistence on the nature of a generative grammar by Chomsky and others. Piaget also speaks of what the child has come to know (in a semi-spontaneous manner); he speaks of the child's competence as consisting of rules and principles which are outside his own awareness, are unstructured in consciousness and yet they are rules which he clearly "knows" and which are as precise as the rules of logic.

Chomsky - and Piaget - are attempting in these investigations an unusual research task. It is to make explicit what it is necessary for an individual to know in order to do what he manifestly does quite well (speak, understand, think, reason). Their objective has been the explication of the rules of the language and of the principles

¹⁷ Ibid., p. 6.

of logic which effectively control observed behavior, but of which the individual himself can give no coherent or adequate account. The explication of these rules will not indicate the steps by which the behavior is produced; it will, instead, describe what must be known by the individual to behave as he does but which (certainly in the case of the child) is inaccessible to awareness. The nature of what is known is inferred from the observation of verbal, logical and non-logical behavior. It is a matter for investigation to determine if instruction may be designed to bring significant aspects of this knowledge to awareness, and if awareness would increase its efficiency, and would make it available in the acquisition of new knowledge and in further development of intelligence.

FURTHER LIMITATIONS OF THE STUDY

In this study only a part of Piaget's immense volume of research has been available, and within the available work, a selection has been made for this report. Other studies conducted by Piaget and his colleagues are pertinent to this field and are available in the original French. Of particular interest will be their research in perception in progress.

Piaget himself has commented that he is not an "easy author." His "difficulty" is in part the extensive knowledge he assumes of language and logic. The limitations of this study in the matter of such a background knowledge is apparent.

PROSPECTS

Instruction in reading as an "applied science" is clearly dependent on fundamental research in related disciplines for its major theoretical orientations. As a "social science" it is also dependent on the culture with its changing social and economic structure and its radical shifts in aspiration and intention for its children.

Reading instruction appears to have been extraordinarily sensitive to suggestions of new directions from these various sources. At present, however, the influences demanding a hearing are far beyond an individual's capacity to deal with them. It seems they may also be beyond the profession's potential capacity for assimilating, integrating and evaluating the radically new.

It appears therefore that it will be necessary to design a co-ordinated approach which will bring together research workers from the related disciplines and workers familiar with reading instruction. At this point, the significant disciplines include at least developmental child psychology, linguistics, modern symbolic logic, and scholars in statistics, language and literature. No immediate solution to problems in reading instruction is to be expected from this co-operation. The disciplines themselves do not have all the knowledge needed for this undertaking, and only they who possess the research techniques specific to a field of study, can supply the theory and the information needed. So there will be gaps -- and waiting.

But the possibilities for successful co-operation, even as matters now stand, are remarkable and exciting. The children of the world will be the beneficiaries. They are waiting too.

BIBLIOGRAPHY

- Apostel, L., W. Mays, A. Morf and Jean Piaget (eds.).
Etudes d'épistémologie génétique. IV. Les liaisons analytiques et synthétiques dans les comportements du sujet. Paris: Presses Universitaires de France, 1957, 41-85.
- Bond, Guy L. and Miles A. Tinker. Reading Difficulties: Their Diagnosis and Correction. New York: Appleton-Century-Crofts, 1957.
- Bruner, Jerome S. "The Course of Cognitive Growth," American Psychologist, XIX, No. 1 (January, 1964), 1-15.
- Canadian Reading Development Series, All Sails Set ed. Ranton McIntosh. Toronto: Copp Clark Company, 1948.
- Carroll, Lewis. Mathematical Recreations of Lewis Carroll, Symbolic Logic and the Game of Logic. New York: Dover Publications Inc., 1958.
- Ceccato, Silvio. "Automatic Translation of Languages," Information Storage and Retrieval, II (June, 1964), 105-158.
- Chomsky, Noam. Aspects of the Theory of Syntax. Cambridge, Mass: M. I. T. Press, 1965.
- Danziger, K. "Children's Understanding of Kinship Terms: A Study in the Development of Relational Concepts," Journal of Genetic Psychology, XCI (March, 1957), 213-232.
- David, H. P. and H. Von Bracken (eds.). Perspectives in Personality Theory. New York: Basic Books, 1957.
- Donaldson, Margaret. "Review of J. Piaget and B. Inhelder, The Early Growth of Logic in the Child," British Journal of Psychology, LI (1960), 181-184.

- A Study of Children's Thinking. London: Tavistock Publications, 1963.
- Festinger, L. A Theory of Cognitive Dissonance. Evanston, Ill.: Row, Peterson, 1957.
- Flavell, John H. The Developmental Psychology of Jean Piaget. New York: D. Van Nostrand, 1963.
- Fodor, Jerry A. and Jerrold J. Katz (eds.). The Structure of Language. New Jersey: Prentice-Hall, 1964.
- Goldstein, K. and J. Scheerer. Abstract and Concrete Behavior: an Experimental Study with Special Tests. Psychological Monograph, LIII, No. 2, 1941.
- Gray, William Scott. The Teaching of Reading and Writing, An International Survey. Paris: UNESCO, 1956.
- Halpern, Esther. "The Effects of Incompatibility Between Perception and Logic in Piaget's Stage of Concrete Operations," Child Development, XXXVI, No. 2 (June, 1965), 491-495.
- Harper, R. J. C., Charles C. Anderson, C. M. Christensen, S. M. Hunka (eds.). The Cognitive Processes: Readings. New Jersey: Prentice-Hall, 1964.
- Hilgard, Ernest R. (ed.). Theories of Learning and Instruction, Sixty-third Yearbook of the National Society for the Study of Education, Part I. Chicago: University of Chicago Press, 1964.
- Hoch, P. H. and J. Zubin (eds.). Psychopathology of Childhood. New York: Grune and Stratton, 1955.
- Inhelder, Bärbel and Jean Piaget. The Growth of Logical Thinking from Childhood to Adolescence. New York: Basic Books, 1958.
- (1959). The Early Growth of Logic in the Child. London: Routledge and Kegan Paul, 1964.
- Jahoda, Gustav. "Children's Concepts of Nationality: A Critical Study of Piaget's Stages," Child Development, XXXV (December, 1964), 1081-1092.

- Kaplan, Abraham. The Conduct of Inquiry. San Francisco: Chandler, 1964.
- Klima, Edward S. "Relatedness Between Grammatical Systems," Language, XL, No. 1 (1964), 1-20.
- Lampard, Dorothy M. Director, Reading and Language Centre, Faculty of Education, University of Alberta. Interview (February, 1965).
- Laurendeau, Monique, and Adrien Pinard. Causal Thinking in the Child. Montreal: Institute of Psychological Research, 1962.
- Lewis, C. I. A Survey of Symbolic Logic. New York: Dover Publications, Inc., 1960.
- McLaughlin, G. Harry. "Psycho-Logic: A Possible Alternative to Piaget's Formulation," British Journal Educational Psychology, XXXIII, Part I (February, 1963), 61-67.
- Miller, G.A. "The Magical Number Seven, Plus or Minus Two," Psychological Review, LXIII (March, 1956), 81-97.
- Miller, G. A., Eugene Galanter, Karl H. Pribram. Plans and the Structure of Behavior. New York: Henry Holt, 1960.
- Miller, G. A. and S. Isard. "Free Recall of Self-embedded English Sentences," Information and Control, VII (1964), 292-303.
- Morf, A., J. Smedslund, Vinh-Bang, and J. F. Wholwill (eds.). Etudes d'épistémologie génétique, IX. Paris: Presses Universitaires de France, 1959.
- O'Connor, N. (ed.). Recent Soviet Psychology. New York: Leveright, 1961.
- Piaget, Jean. (1926). The Language and Thought of the Child. London: Routledge and Kegan Paul, 1962.
- (1927). The Child's Conception of the World. London: Routledge and Kegan Paul, 1951.
- (1927). The Child's Conception of Physical Causality. New Jersey: Littlefield, Adams, 1960.
- (1928). Judgment and Reasoning in the Child. London: Routledge and Kegan Paul, 1962.

(1936). The Origins of Intelligence in Children.
New York: Norton, 1963.

(1941). The Child's Conception of Number.
London: Routledge and Kegan Paul, 1961.

(1941). Le développement des quantités physiques
chez l'enfant. Neuchatel, Suisse: Delachaux et
Niestlé, 1962.

(1945). Play, Dreams and Imitation in Childhood.
New York: Norton, 1951.

(1947). The Psychology of Intelligence.
London: Routledge and Kegan Paul, 1959.

(1948). The Child's Conception of Space.
London: Routledge and Kegan Paul, 1956.

(1948). The Child's Conception of Geometry.
London: Routledge and Kegan Paul, 1960.

Logic and Psychology. Manchester: Manchester
University Press, 1953.

Quine, Willard Van Orman. Elementary Logic. Boston:
Ginn, 1941.

Raven, J. C. Progressive Matrices. New York: The Psychological
Corporation, 1949.

Smedslund, J. "The Acquisition of Conservation of Substance
and Weight in Children. I. Introduction,"
Scandinavian Journal of Psychology, II (1961),
11-20.

"The Acquisition of Conservation of Substance and
Weight in Children. II. External Reinforcement
of Conservation of Weight and of the Operations of
Addition and Subtraction," Scandinavian Journal of
Psychology, II (1961), 71-84.

"The Acquisition of Conservation of Substance and
Weight in Children. III. Extinction of Conservation
of Weight Acquired 'Normally' and by Means of Empirical
Controls on a Balance Scale," Scandinavian Journal
of Psychology, II (1961), 85-87.

"The Acquisition of Conservation of Substance and Weight in Children. IV. An Attempt at Extinction of the Visual Components of the Weight Concept," Scandinavian Journal of Psychology, II (1961), 153-155.

"The Acquisition of Conservation of Substance and Weight in Children. V. Practice in Conflict Situations without External Reinforcement," Scandinavian Journal of Psychology, II (1961), 156-160.

"The Acquisition of Conservation of Substance and Weight in Children. VI. Practice on Continuous versus Discontinuous Material in Conflict Situations without External Reinforcement," Scandinavian Journal of Psychology, II (1961), 203-210.

Strickland, Ruth G. The Language of Elementary School Children: Its Relationship to the Language of Reading Textbooks and the Quality of Reading of Selected Children. ("Indiana University, Bulletin of the School of Education, XXXVIII, No. 4"), Bloomington, Indiana: Bureau of Educational Studies and Testing, 1962.

The New Basic Readers, The New Friends and Neighbors ed. William S. Gray, Sterl Artley, May Hill Arbuthnot. Toronto: W. J. Gage and Company, 1956.

Vygotsky, L. S. Thought and Language. Cambridge, Mass: M. I. T. Press, 1962.

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